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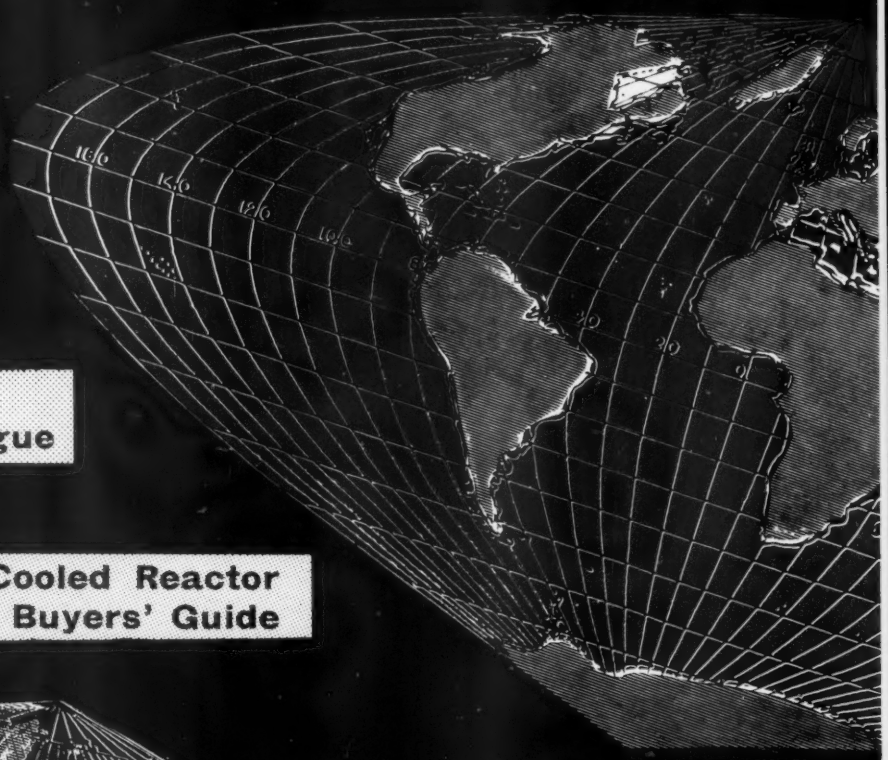

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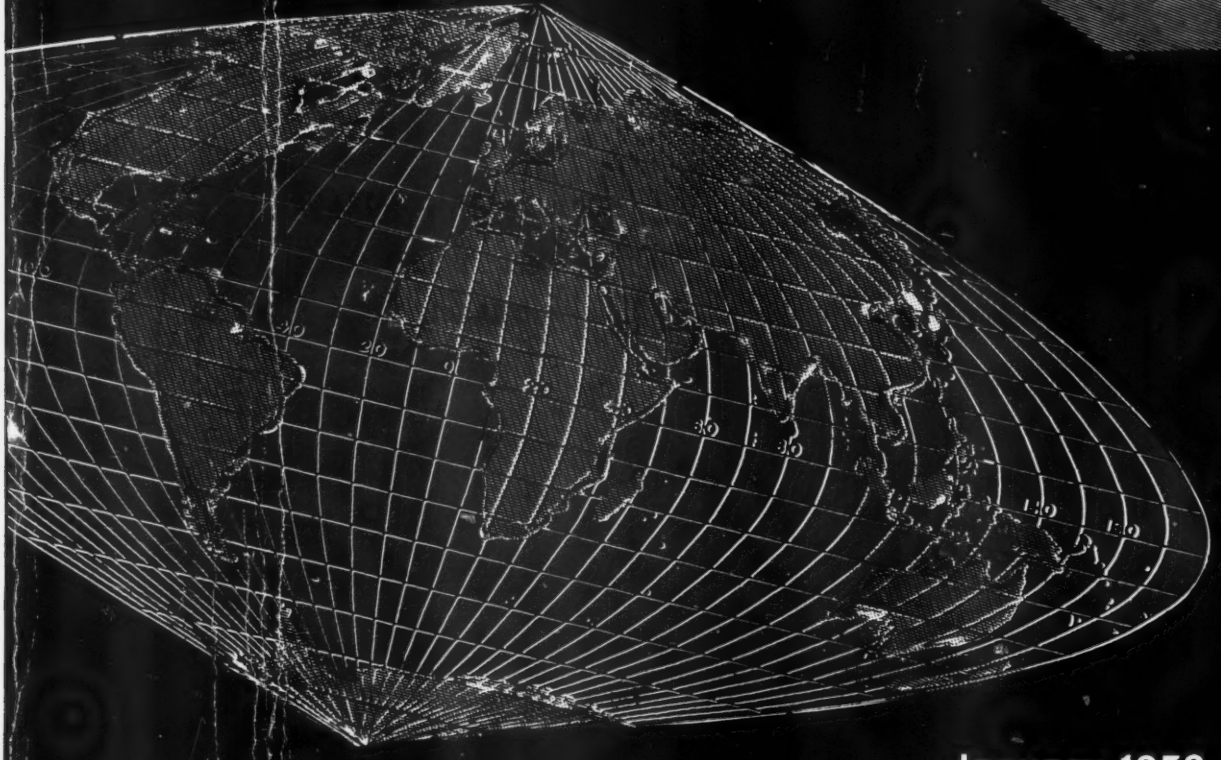

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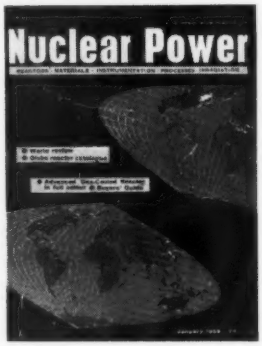

VOL 4 NO 33 JANUARY 1959

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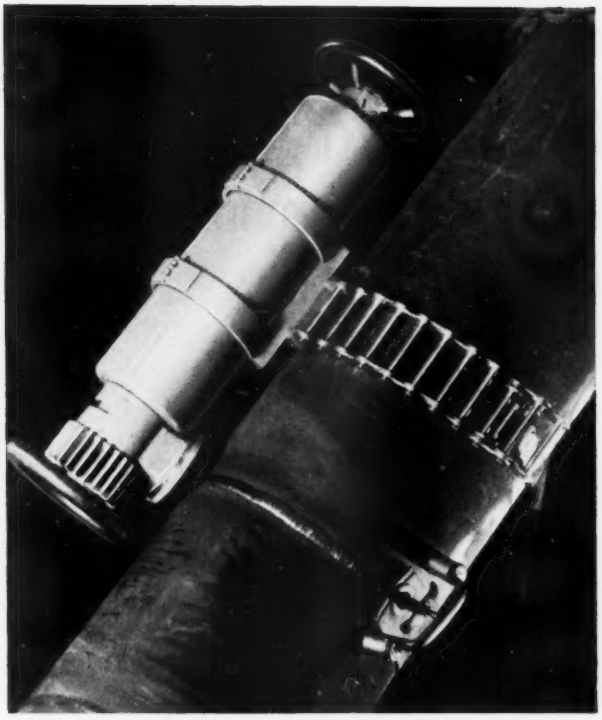
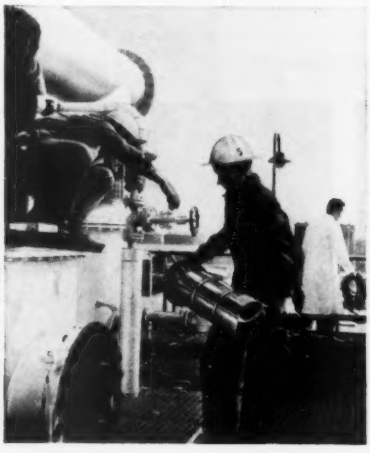
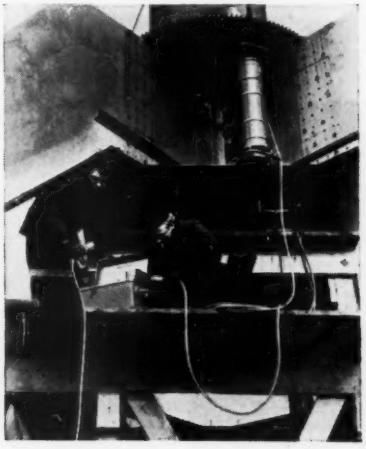


Examining a welded joint in a pipe-line. 'MACROTANK D' supported by adjustable quick-acting clamp. Fine-focus tube (focal-spot size only 1.5 mm!) gives high definition even at short focus-film distances.

Inspecting the tail structure of a large passenger-carrying aircraft. On account of its performance and portability airline operators rate the 'MACROTANK D' very highly. Many famous firms in the aviation industry use Müller equipment.



Weld inspection at an oil refinery. Moving a 'MACROTANK D' to another part of the site. For open-ended vessels, circumferential welds can be radiographed from within; up to 120° with a single exposure or 360° with Model F.



Site welding inspection with the 'MACROTANK H'. This unit has a penetration of 3¼" of steel. Tension variable over the range 60-260 kV (stepless). Ideal for shipyard work and bridge construction. Provided with outdoor-type (rainproof) control box.

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British Patent No. 474008, 720074, 720075, 697987, 65318
U.S.A. Patent No. 2129320

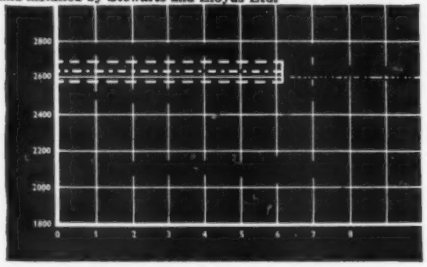
Ferrybridge 'B' Power Station, Central Electricity Generating Board, Yorkshire Division. H.P. Steam pipes supplied and installed by Stewarts and Lloyds Ltd.

Leibfried Red Top Pipe Supports for load from 100 to 5,000 lbs. and total travel of 3″

Conventional type "Con-Ten" Supports for loads of up to 2 tons with a total vertical movement up to 12″.

Duplex "Con-Ten" Supports for loads of up to 8 tons with a total vertical movement up to 12″. This type is acknowledged as one which produces minimum friction and kinematic variation. It has been specially designed for any applications where exceptional accuracy is demanded,

From graph it can be seen that the maximum friction is equivalent to 2.17% of the applied load.



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Fielden AUTOMATION

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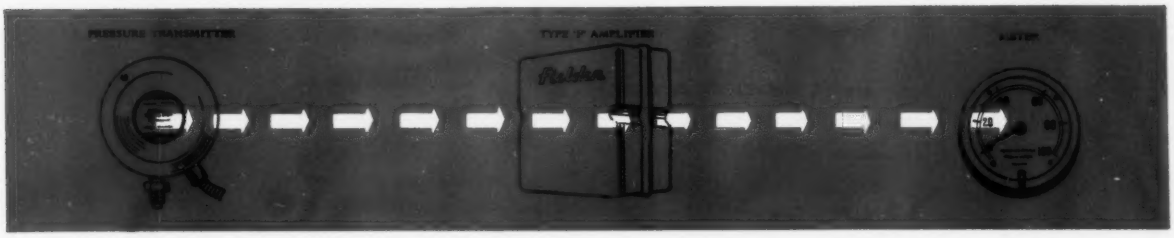
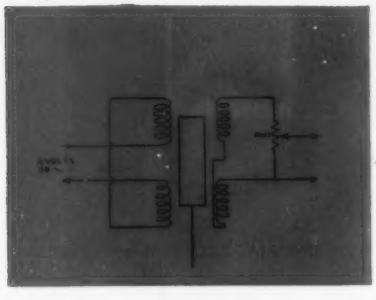


The Fielden system of Remote Indication of Pressure has all the advantages of electrical transmission and yet is so very simple.

The range of equipment covers transmitters for Gauge Pressure, Vacuum, Absolute Pressure and Differential Pressure but in each case the indicating equipment is precisely the same — an important fact from the point of view of spares and maintenance.

Principle of operation

In each Fielden Pressure Transmitter there is a small differential transformer and the output of the transformer depends upon the positioning of a ferroxcube core. This core is positioned by a bourdon tube, diaphragm or bellows depending upon the range. In order to simplify the equipment the differential transformer has been designed to operate on 50 cycles but the voltage is very low and the transformers can be handled, in operation, with perfect safety.



Type 'F' Amplifier

The Type 'F' Amplifier itself is a simple stable amplifier which accepts the signal from the Differential Transformer and amplifies it to the stage when it can be used for direct indication on a moving coil meter.

The Type 'F' Amplifier can be located close to the Transmitter or the indicating meter, whichever is the more convenient, and requires little or no maintenance.

Indicating Meters

Indicating Meters with 300 degrees scale, 6" diameter are available as standard, but other patterns and sizes to match other instruments are available.

Schemes available

This Fielden pressure transmission system can be used for single point applications where one pressure is continuously indicated on one meter or a number of transmitters can be switched to one indicator.

Transmitters

The High Pressure and Low Pressure Transmitters are illustrated below. These are supplied with standard B.S.P. threads and are screwed into the point of measurement. Simple electrical connections are used to transmit the information to the Indicator.

Ranges

The minimum range of pressure for this equipment is 0-10" w.g. and the maximum standard range is 0-15,000 p.s.i. although higher ranges can be covered to special order.

If you are interested in Remote indication of PRESSURE, VACUUM or FLOW, please write for further information to :—

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HEAT EXCHANGERS

- 3 -

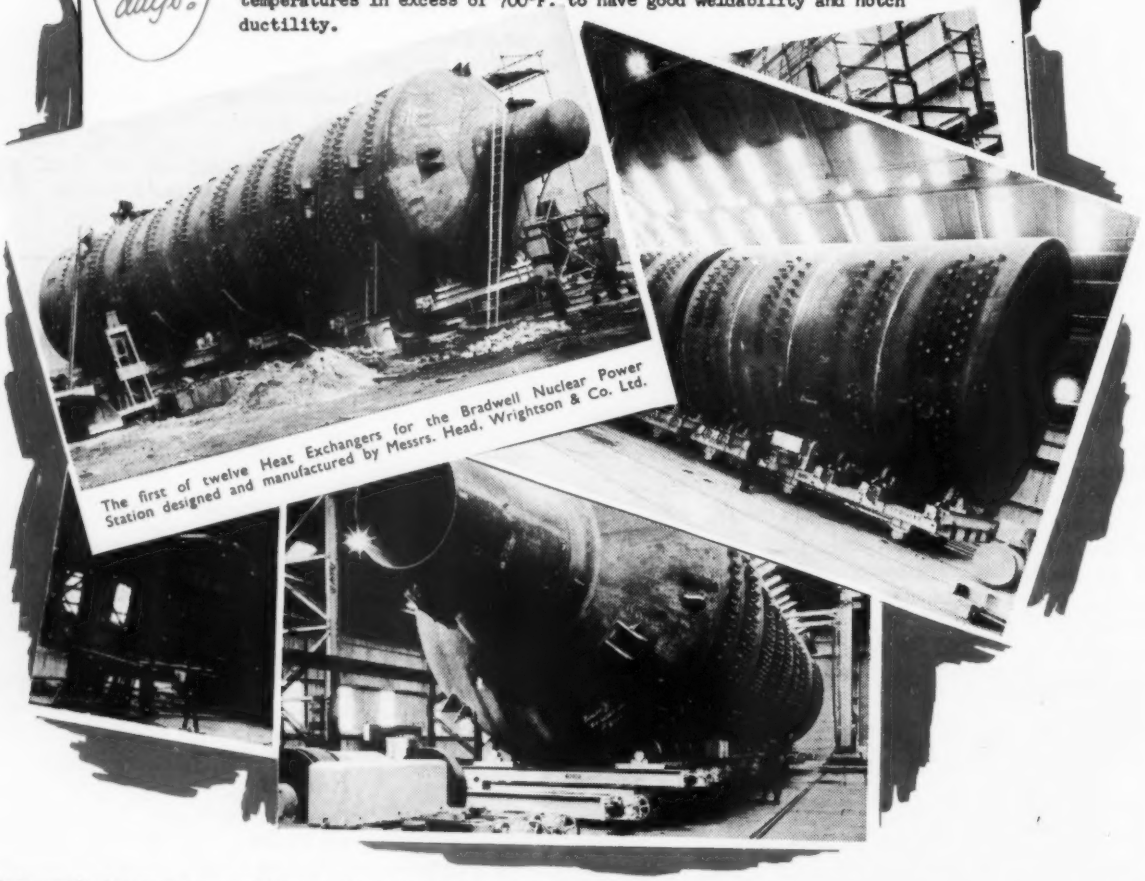
under strict control, launching them into the river, towing and hauling out of the river at site was the best answer to the problem.

FABRICATION DETAILS

All plate material used in these vessels was supplied by Consett Iron Company, Ltd. The shell plate was specified to have an U.T.S. of 28/32 tons/sq. inch, and an elongation of 20% on 8 inch gauge length, the dished ends needing to be a more ductile quality, with an U.T.S. of 26/30 tons/sq. inch and an elongation of 23% on a similar gauge length.

The steel was also required to be suitable for service at temperatures in excess of 700°F. to have good weldability and notch ductility.

They're doing a lot of special steels these days!



The first of twelve Heat Exchangers for the Bradwell Nuclear Power Station designed and manufactured by Messrs. Head, Wrightson & Co. Ltd.

Photographs by permission of Messrs. Head, Wrightson & Co. Ltd., who designed and manufactured the Heat Exchangers.

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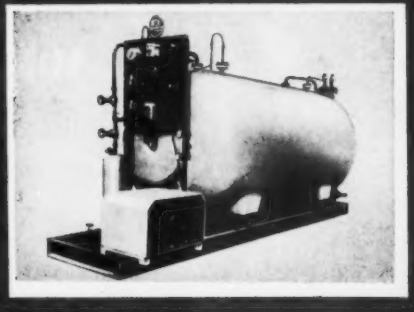
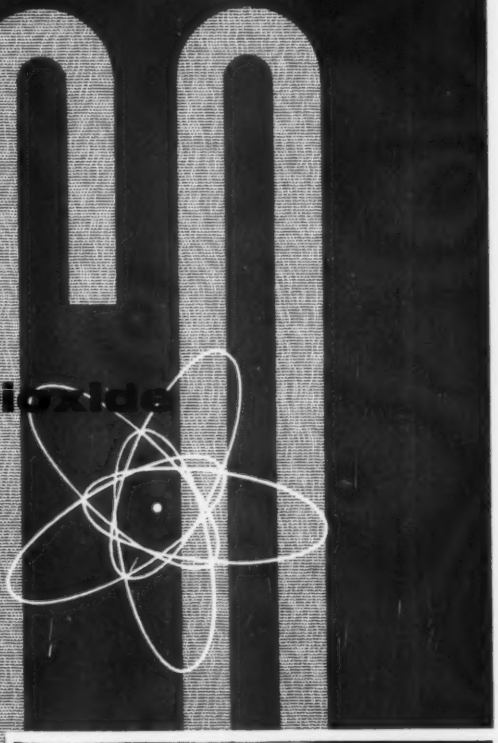


Without effort and without loss, I.C.I. carbon dioxide, which meets the exacting requirements of the U.K. Atomic Energy Authority, is always on tap, where and when it is wanted.



CO_2

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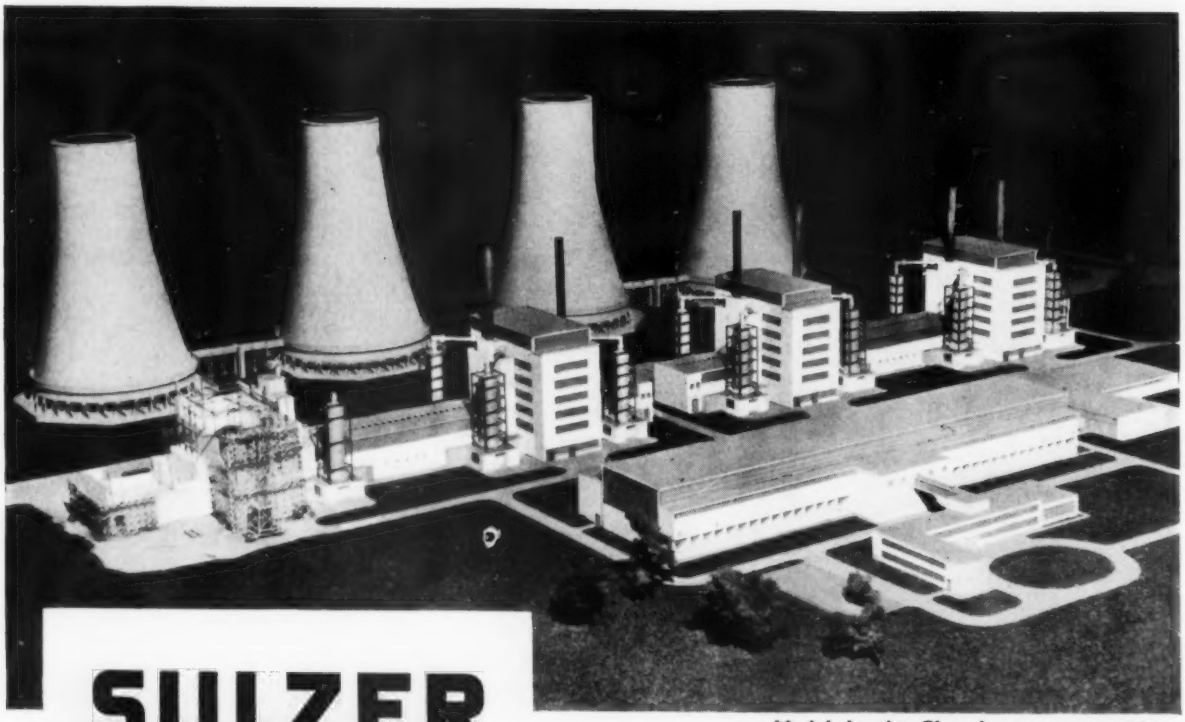

Model showing Chapelcross power station

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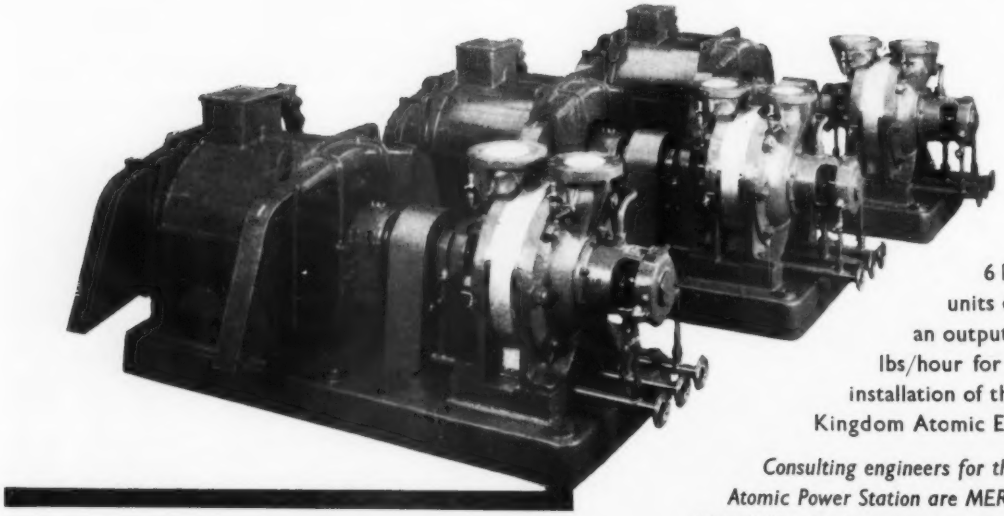

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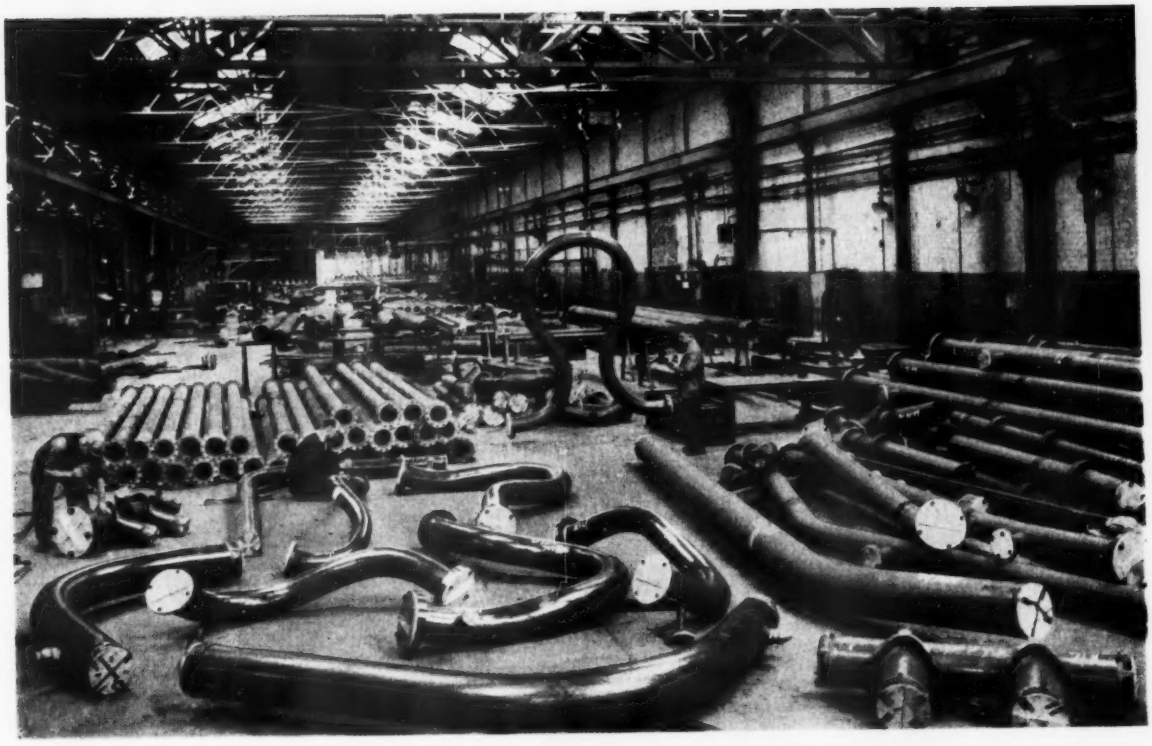
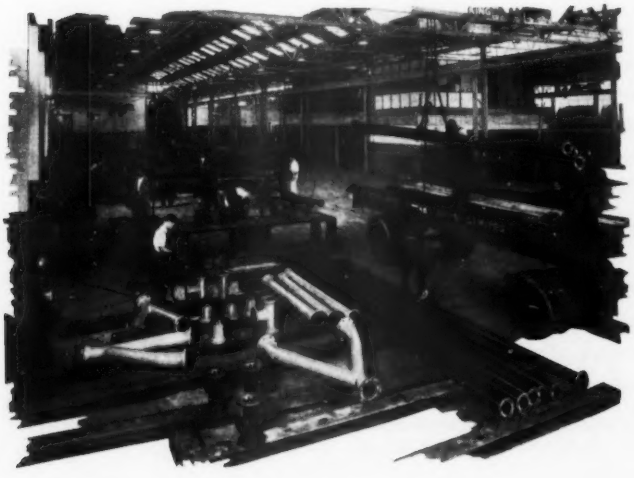
MANIPULATED PIPEWORK



ABOVE: *Manipulated high pressure pipework in the assembly, inspection and despatch bays at Stewarts and Lloyds' Tollcross Works, Glasgow.*

BELOW: *New fabricating shop at Pudding Mill Lane, Marshgate Lane, Bow, E.15.*



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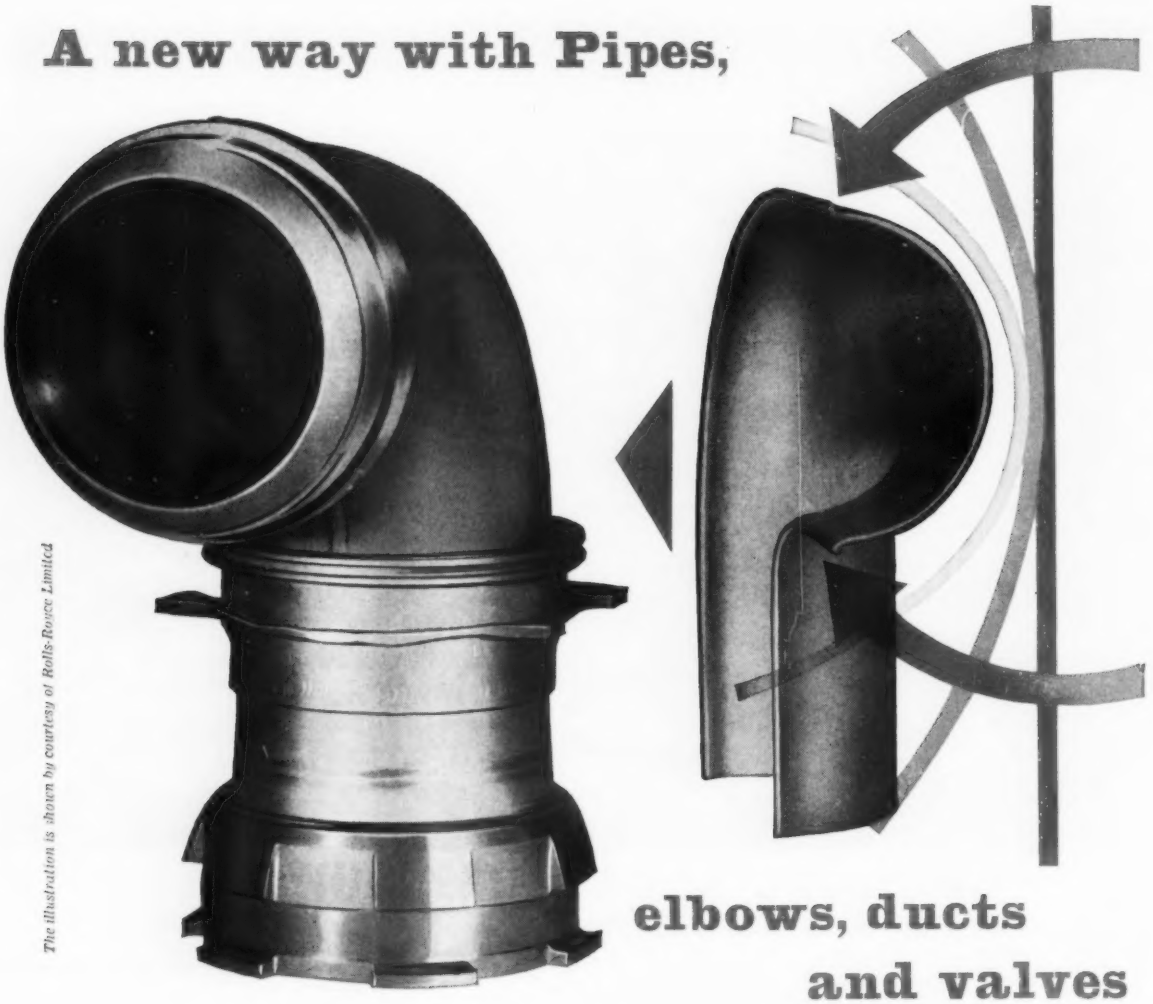

The illustration is shown by courtesy of Rolls-Royce Limited

elbows, ducts and valves

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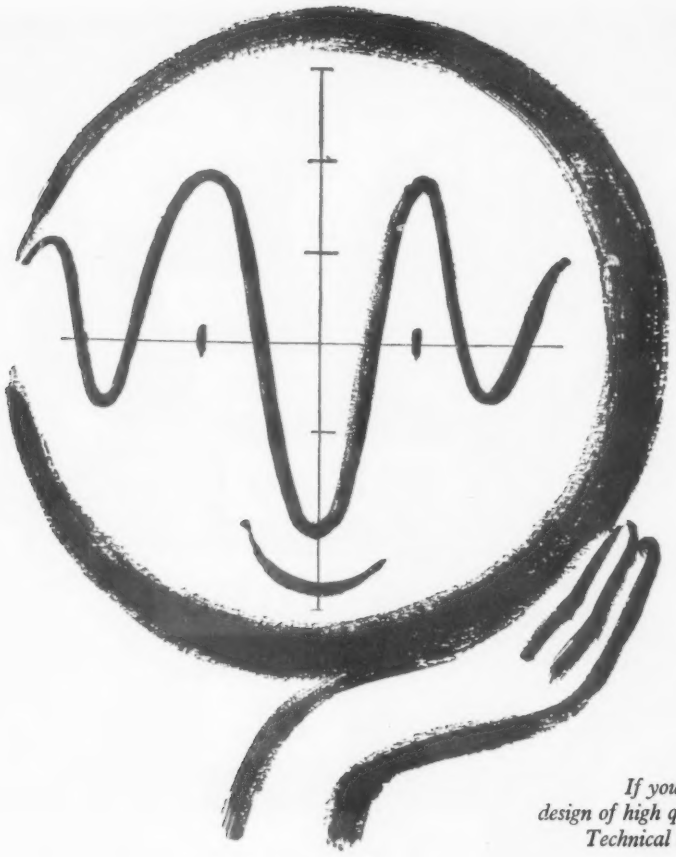
The illustration shows a typical component which forms part of the external anti-icing ducting of the Rolls-Royce Conway engine. This system has metal spherical sealing faces and transmits air at elevated temperatures and pressures with a minimum of leakage.

If you have an application for this new method we should be pleased to investigate and advise.

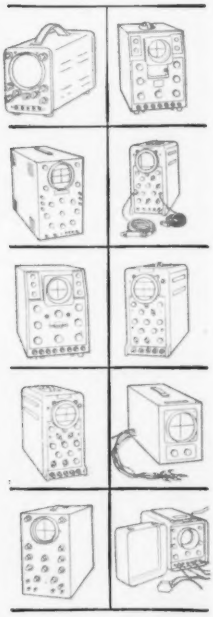
Wilmot Breeden are skilled in metal manipulation

Wilmot Breeden Ltd., Birmingham



If you are experienced in the design of high quality instruments, our Technical Director would be glad to hear from you.

Thinking about an oscillograph?



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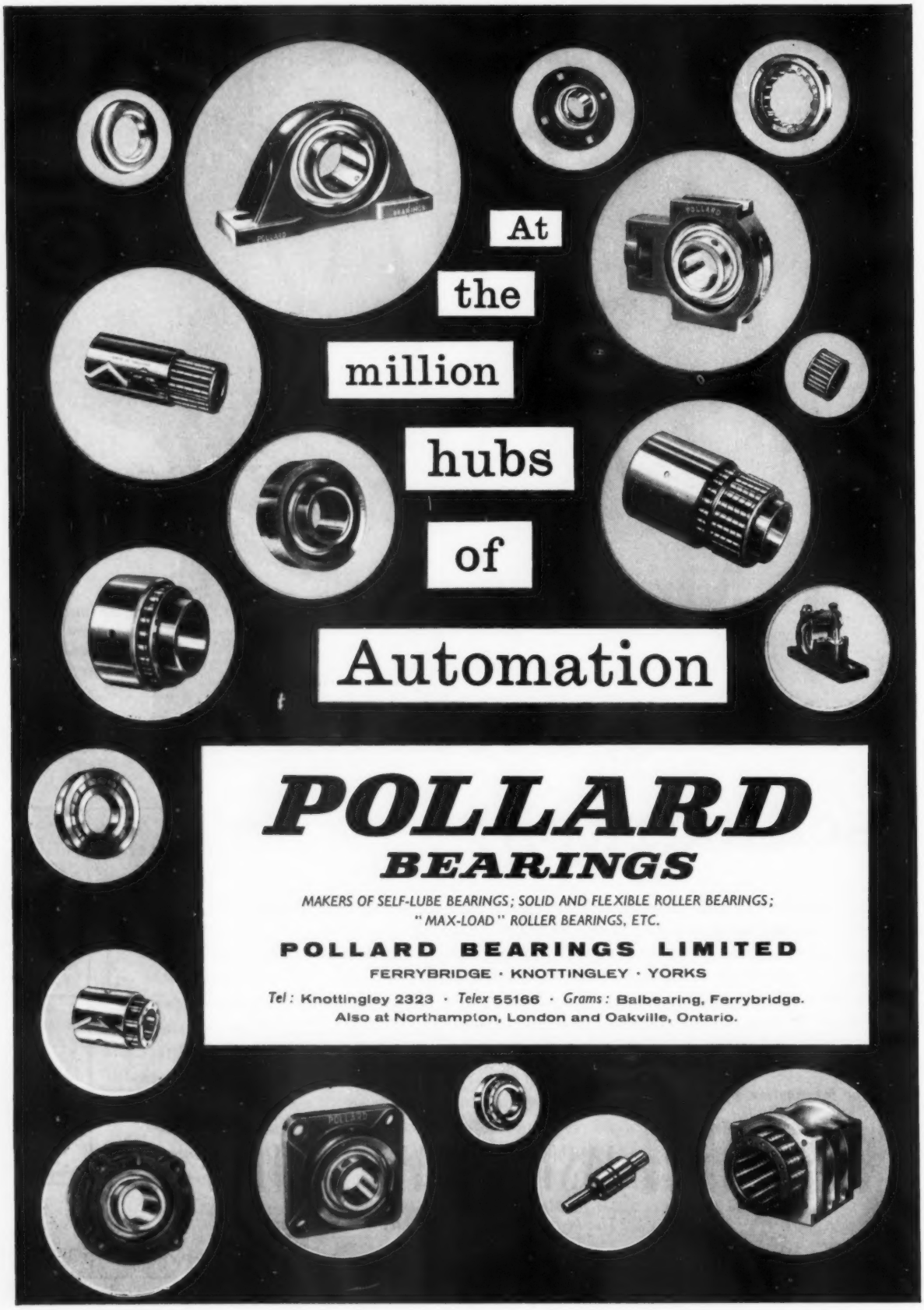

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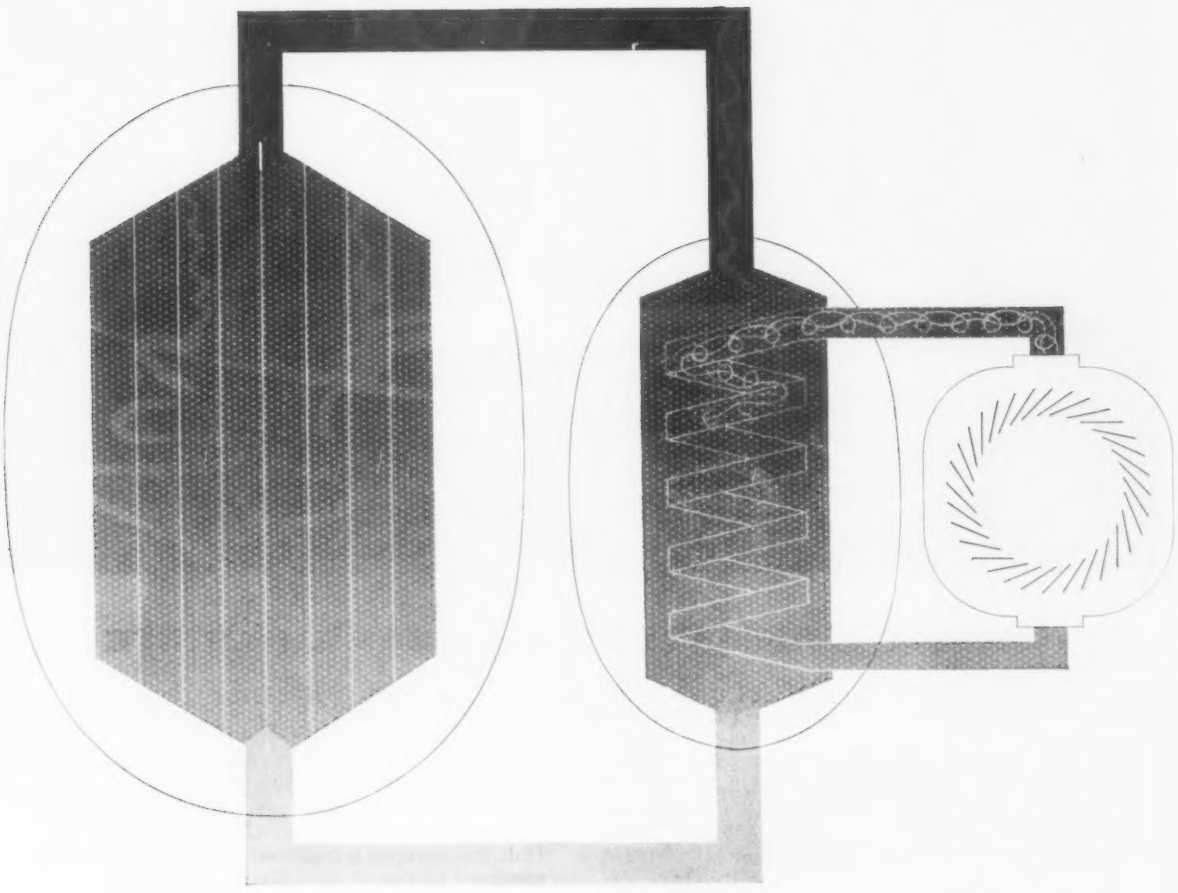

The D.C.L. system of liquid carbon dioxide bulk storage and vaporisation used at Calder Hall and now installed at Chapelcross provides the vital link in the transfer of heat from the heart of the reactor to the steam-raising plant. D.C.L. skill, developed through 30 years' experience in the manufacture, bulk transport and storage of the purest liquid CO_2, has played no small part in the creation of Britain's lead in the industrial use of atomic power. Installations at Berkeley, Bradwell, Hunterston and Hinkley Point, already in active preparation, will add further strength to British economy.

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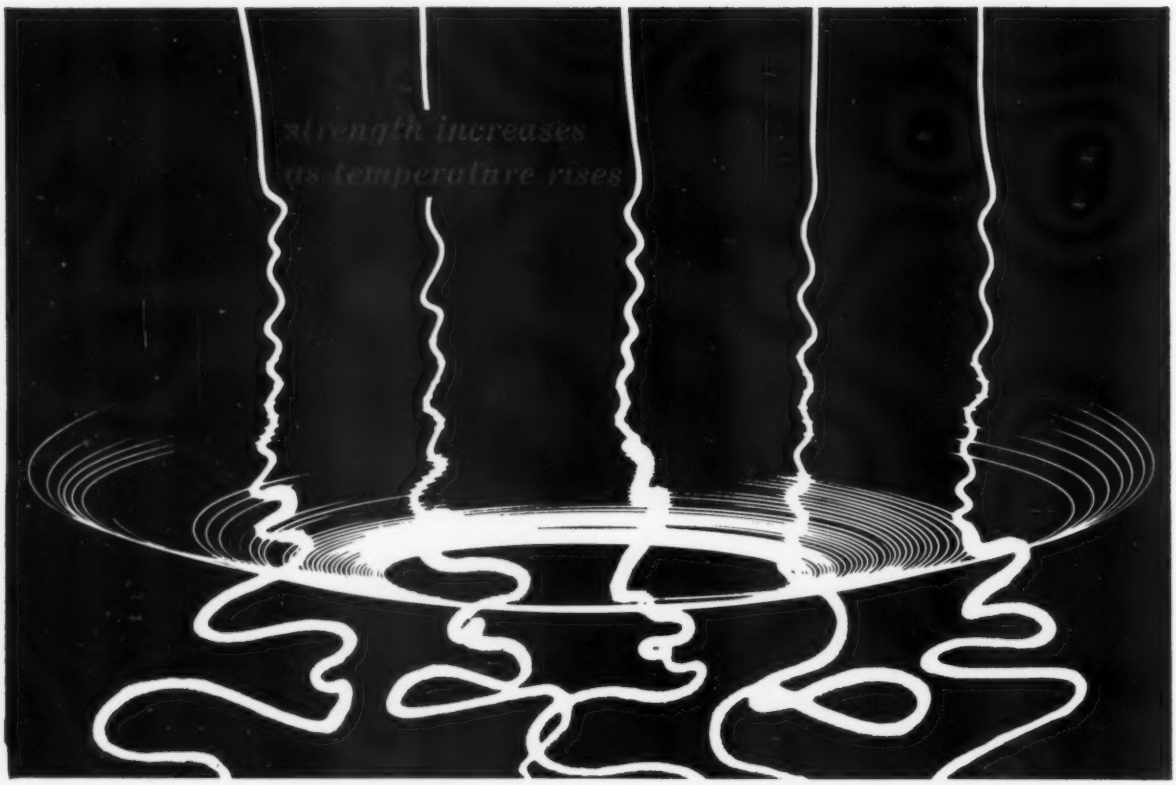

UNION CARBIDE'S NUCLEAR GRAPHITE

for Moderators, Reflectors, Thermal Columns, Molds and Crucibles

Reactor components of UNION CARBIDE's nuclear graphite withstand tremendous heat—gaining in strength as temperature rises... gaining in strength when these components need that added strength.

For example, compression strength at 1600 deg. C. is 15% to 24% higher than at room temperature. And strength increases steadily all the way to the 2500 deg. level. Tensile strength at 450 deg. C. is approximately 3000 psi (211 kg/cm^2). At 1350 deg. C. it measures 4000 psi (281 kg/cm^2) and at 2500 deg. C. it reaches 5000 psi (352 kg/cm^2). Here we have a 67% increase in tensile strength from 450 deg. C. to 2500 deg. C.—a temperature exceeding the melting point of most metals!

In addition, low neutron absorption cross section, easy machinability and reasonable cost—combine to make UNION CARBIDE's nuclear graphite foremost in many reactor programs. Great Britain's Calder Hall, for example, is equipped with nuclear graphite produced by one of our affiliated companies.

Whatever your needs—extreme purity, unusual shapes or sizes, high or low density, write to the leader in nuclear graphite, Union Carbide International Company, Division of Union Carbide Corporation, 30 East 42nd Street, New York 17, New York, U.S.A., Cable Address: UNICARBIDE, New York—or contact the company listed below which is nearest you:

ITALY
Elettrografite di Forno Allione, S.A.
Via Durini 28
Milan, Italy

FRANCE
Compagnie Industrielle Savoie Acheson
Boite Postale 78-08
Paris VIIIe, France

ENGLAND
British Acheson Electrodes Limited,
Grange Mill Lane Wincobank
Sheffield, England

SWEDEN
Skandinaviska Grafitindustri A/B
P.O. Box 79
Trollhättan, Sweden

EUROPE
Union Carbide Europa, S.A.
40 rue du Rhone
Geneva, Switzerland

UNION CARBIDE

The term UNION CARBIDE is a trade mark of Union Carbide Corporation.

AY-IE58

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OR ANY SUITABLE
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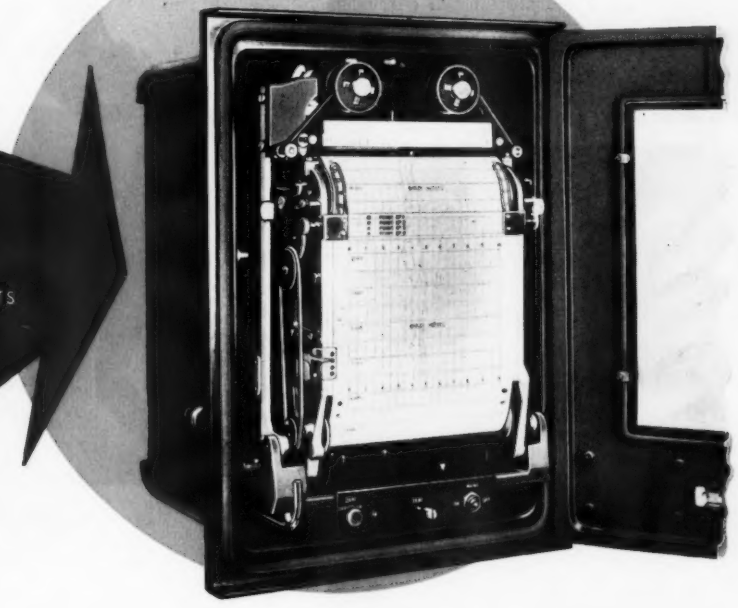

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Provision for 4 independent records—each colour coded differently.
4 chopper-bar operations every 30 seconds.
Long-life chart and ink ribbon.
Fully sealed oil-immersed servo motor and slide wire.
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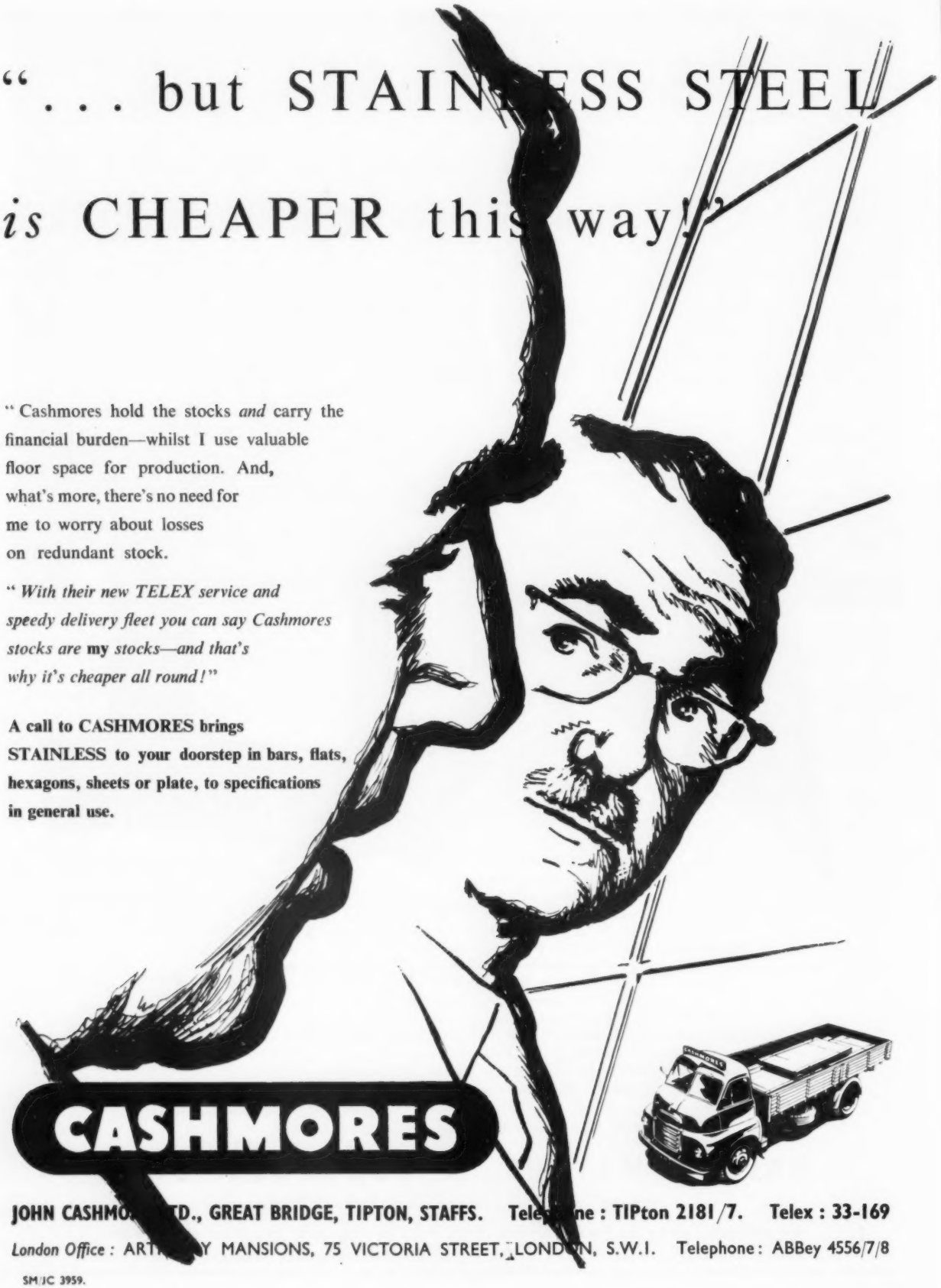
"... but STAINLESS STEEL *is* CHEAPER this way!"



" Cashmores hold the stocks *and* carry the financial burden—whilst I use valuable floor space for production. And, what's more, there's no need for me to worry about losses on redundant stock.

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London Office : ART[illegible]Y MANSIONS, 75 VICTORIA STREET, LOND[illegible]N, S.W.1. Telephone : ABBey 4556/7/8

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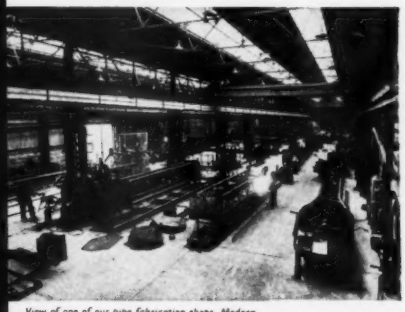
PIPE

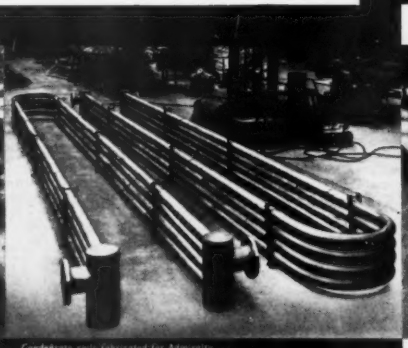
Aerial view of Crown Works, Sunderland

World famous for every kind of pipe fabrication in a wide variety of materials, STEELS and LOW'S are producing installations of exceptional quality and accuracy – for the marine, chemical and oil industries, the great nationalised industries, and atomic energy projects.



View of one of our pipe fabrication shops. Modern manipulators in foreground.

Another example of our many fabrications. Bends are machine made cold and unfilled, and stress-relieved.



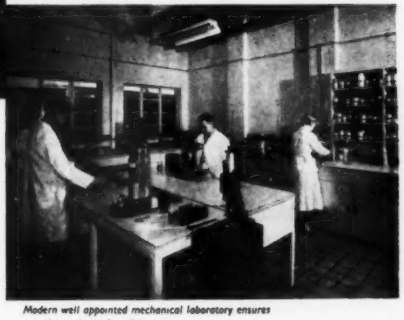
Condensate coils fabricated for Admiralty.

Aluminium alloy cargo line piping, 8" nom. bore x 4 SWG thick, flanges ½" thick.

Pipe layouts are speedily prepared from site measurements and drawing details, backed by comprehensive metallurgical and testing laboratory facilities. Fabrication methods include all new and established principles of manipulation, welding, flanging and screwing in all materials normally used in the manufacture of tubes. Fabricated to British and American standards.

Special mild steel pipework for high pressure hot water process circuit.

FABRICATION



Modern well appointed mechanical laboratory ensures a high standard of prefabrication.

STEELS ENGINEERING INSTALLATIONS LTD., Sunderland,

and their Associates ARCHIBALD LOW & SONS LTD., Glasgow.
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Tel: Sloane 6178

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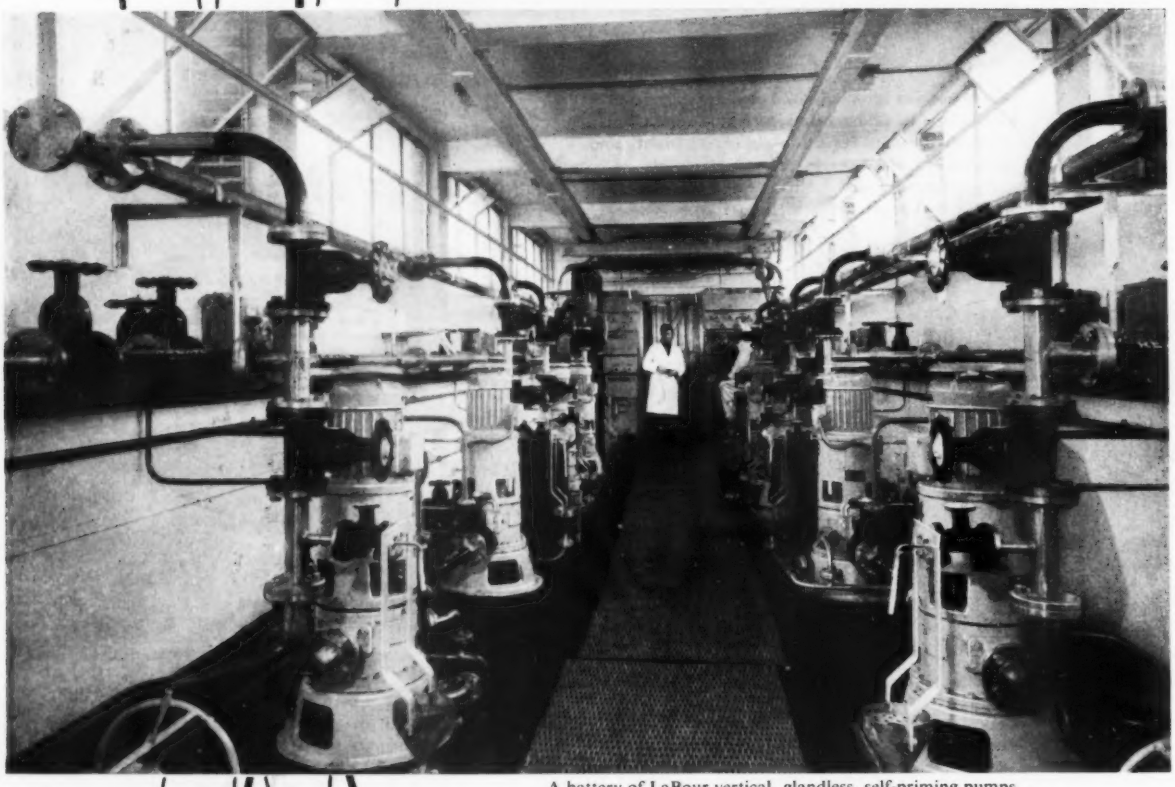


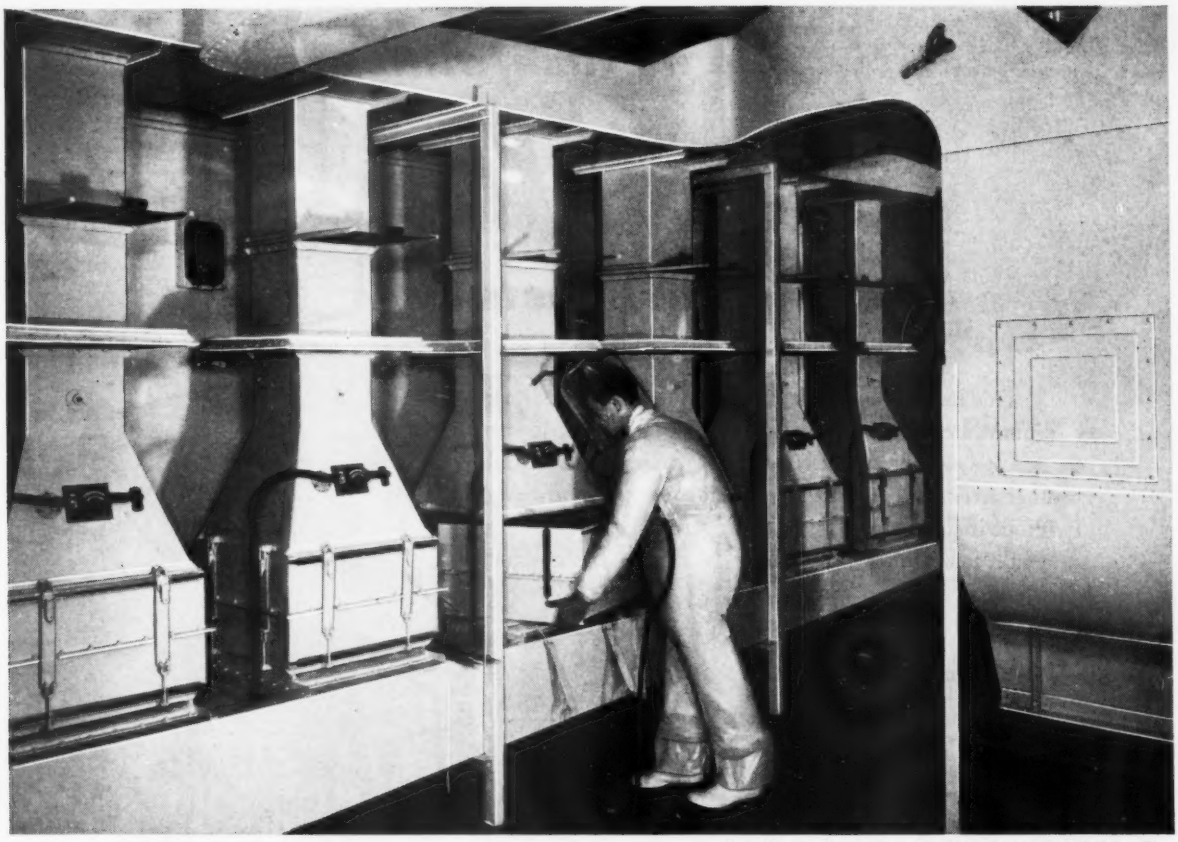
A battery of LaBour vertical, glandless, self-priming pumps.
(Photograph by courtesy of the United Kingdom Atomic Energy Authority)

More than 250 LaBour pumps have been installed at one establishment alone of the U.K.A.E.A. Whether it is liquors or slurries, chemicals or effluents, mine dewatering etc., experienced engineers repeatedly specify LaBour pumps. They know that the simple, one-moving-part design assures uninterrupted service, long life and reduced maintenance. They appreciate the 'extra' features that LaBour pumps have—extra thick sections and extra heavy bearings which mean rigidity; the extra deep stuffing box; and the extra special materials which give extra resistance to corrosion and erosion.

LABOUR

BRITISH LaBOUR PUMP CO. LTD. BLUNDELL ST. LONDON N7 Tel: NORTH 6601-5

P2320



One of two banks of Vokes 'Absolute' filters in the G.E.C. beryllium laboratory, showing operator in a pressure suit changing a filter.

Vokes Filters specified for work on Beryllium

New Beryllium Laboratory

At the G.E.C. Atomic Energy Division at Erith a new laboratory has been specially designed for work on beryllium. Vokes were called in to assist in the planning of a ventilating system designed to maintain a very high standard of safety and to conform with the recommendations of the U.K.A.E.A.

A Vokes filter can be seen on the left of the lathe enclosed in the PERSPEX working box.

Vokss 'Absolute' Filters

The laboratory areas are fully air-conditioned by means of a central inlet air duct and there is a range of extract ducting running along the laboratory walls.

The extraction system consists basically of a fan drawing air at the rate of 8,000 cub. ft. per min. from the laboratory through 12 Vokes 'Absolute' filters arranged in two banks of six, coupled in parallel to the extract fan. Each of these filters is individually mounted in a cell on the manifold to minimise hazards during filter changing.

The Vokes 'Absolute' filter has a guaranteed efficiency of 99.95% in the 0.1 to 0.5 micron range. For particles greater than 1 micron the efficiency is virtually 100%. The plant has been arranged so that the filters can be changed with the ventilation plant running.

Working Boxes fitted with Vokes Filters

Operations involving the formation of beryllium dust, such as machining, abrasion and welding, are confined to a laboratory where the highest ventilation rate is available and is carried on in ventilated working boxes, which also incorporate Vokes filters.

Where filtration to a particularly high standard is required, as in this case at Erith, Vokes filtration experts are available from planning stage to final installation. If you have a filtration problem, please contact us.

VOKES

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VOKES—Air and Gas Filters for Chemical, Nuclear Energy, Oil Refinery, and Pharmaceutical applications etc; Air conditioning filters; Compressed air pipe line filters; Air, Oil, and Fuel filters for Diesel, Gas Turbine, and other i.c. engines; Hydraulic filters; Silencers for Engines, Fans and Blowers; High efficiency Multi Cyclones.

V.315

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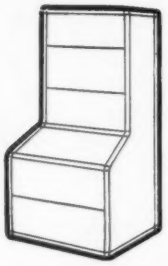
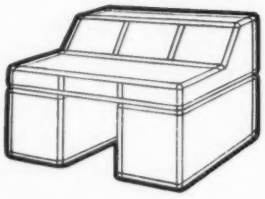
and cut out tool costs!



This unique, low-cost construction system comprises aluminium alloy extrusions and locking corner connectors. It's simplicity itself: precision cases, cabinets and other structures can all be quickly built to your own design without incurring tool costs. Smart . . . speedy . . . strong . . . you'll find Imlok a boon for research and prototype work and so often the answer to a production problem too. Write now for full information.



Here's the secret of IMLOK'S strength

The extrusions slide over the long arms of the connector - overlapping and gripping it to give positive lock

IMLOK ***cheapest in the short run . . . cheaper in the long run***

ALFRED IMHOF LIMITED Dept. N.1 Ashley Works Cowley Mill Road Uxbridge Middlesex Telephone: UX5-5567

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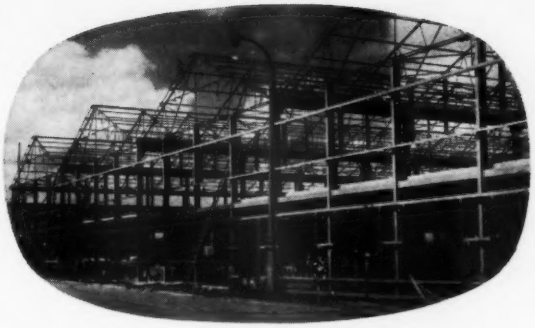
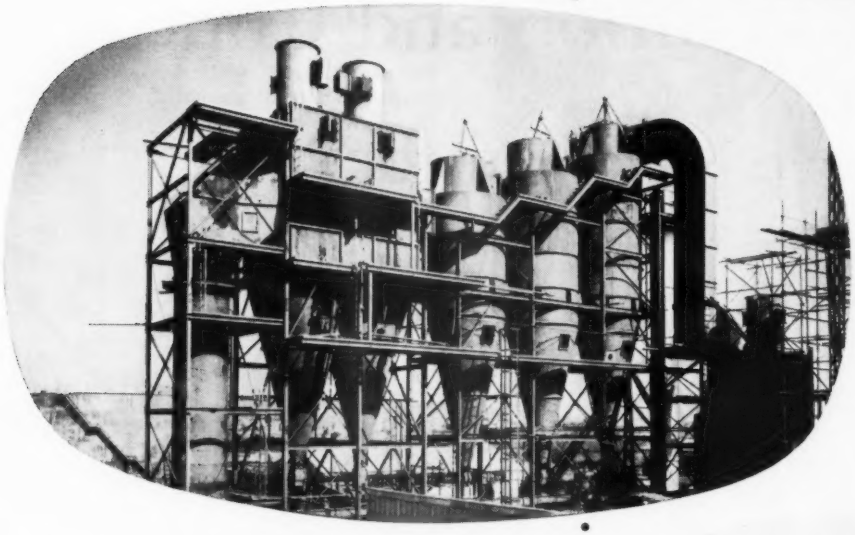
Welding





Structures ▲

Part of 2,000 ton contract for U.K. Atomic Energy Authority, Springfields Plant, Preston

Pressure Vessels

Pressure Vessel for Shell Petroleum Co. Ltd. 90ft. long 9ft. dia. All welds X-rayed. Dead weight 40 tons. ▼

The photograph above shows site welded Cyclones and Precipitators with supporting structures.

Inspection facilities include laboratory equipped with up-to-date testing machines and radiography.

New bay on Works now completed — production area increased by 35,000 sq. ft.

STEELWORK

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Robert Watson & Co.
(CONSTRUCTIONAL ENGINEERS), LIMITED
Bolton, Lancs.
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and Bristol
Telephone: Filton 2361

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Instrumentation and Control

is specified for

Nuclear Projects

because of its

Flexibility and Simplicity

EVERSHED's are supplying instrumentation equipment for the nuclear energy project at Hunterston and for the new G3 reactor in France. EVERSHED equipment has already been installed at Windscale, Aldermaston and Dounreay. These projects are but a few for which the EVERSHED electronic instrumentation equipment was specified.

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7/8NN

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COLES' 80 years of specialised experience in the production of Cranes has put them years ahead. Developed to serve Britain's future needs, the new COLES Cranes are as modern as your industry they serve.
Send now for the latest Coles literature.
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COLES
DIESEL-ELECTRIC CRANES
CAPACITIES 5 TO 50 TONS

Designed, manufactured and marketed by:—

STEELS ENGINEERING PRODUCTS LIMITED, Sunderland, England. *Tel: 56281 (10 lines) Grams: Steel, Sunderland.*
SALES AND SERVICE: **Birmingham:** 39 Thorp St., 5. **Glasgow:** 235 Bath St., C.2.
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COLES THE NAME THAT CARRIES WEIGHT

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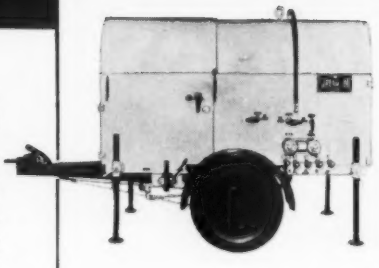
STREAM-LINE FILTERS AND NUCLEAR POWER

The security of oil-immersed circuit breakers or transformers depends on the condition of the oil. In Stream-Line filters the engineer has at his disposal equipment specially designed for the complete removal of contamination in insulating oil and which meets the most stringent requirements. That's why Stream-Line filters have been specified for Chapel Cross and Berkeley, and are in wide use throughout the U.K.A.E.A. A single passage through a Stream-Line filter ensures the elimination of solid impurities, even the finest colloidal carbon; dehydration, including the removal of dissolved water, and de-aeration, including the removal of dissolved gases. A dielectric strength far above that specified for the highest quality new oil is achieved by a standard Stream-Line filter. Our research and development department will be glad to answer your queries. Write for Catalogue W.1031.

A WORD ABOUT HIGH VACUUM

Stream-Line filters designed to operate under high vacuum can be supplied. Details are available on request of models yielding remarkable performances. For most requirements the standard Stream-Line filter gives precisely the service demanded.



A fully mobile Stream-Line filter.

STREAM-LINE FILTERS

STREAM - LINE FILTERS LTD · INGATE PLACE · LONDON · S.W.8

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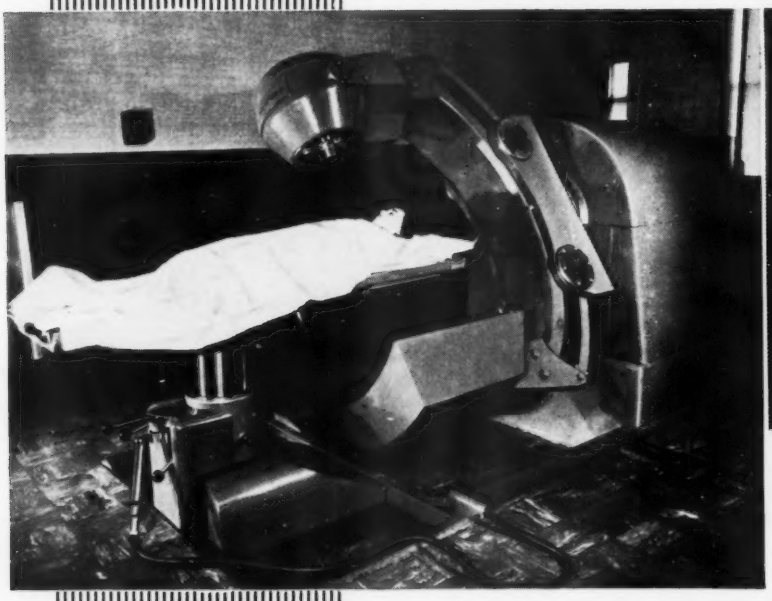
SF/29

G.E.C.

TUNGSTEN BASE

Heavy Alloy

Supplied in densities from 16·7 to 18·0 g/cc.



For Gamma Absorption

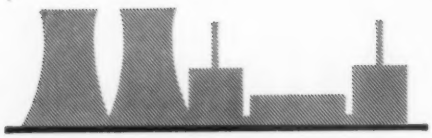
An orbital teletherapy unit using G.E.C. Heavy Alloy.
With acknowledgements to Atomic Energy of Canada Ltd.

A 6″ G.E.C. Heavy Alloy Sphere weighing 65 lbs. being placed in an 8″ lead wall in the Isotope Division, Harwell.

Informative publication No. 3861 on application.

G.E.C.

THE GENERAL ELECTRIC COMPANY LIMITED, Component Sales Dept., Osram Metals Division, East Lane, Wembley, Middlesex.



the latest techniques in nuclear engineering...

Drilled and machined flanges for Atomic Energy Power Stations

...demand special alloy steel forgings

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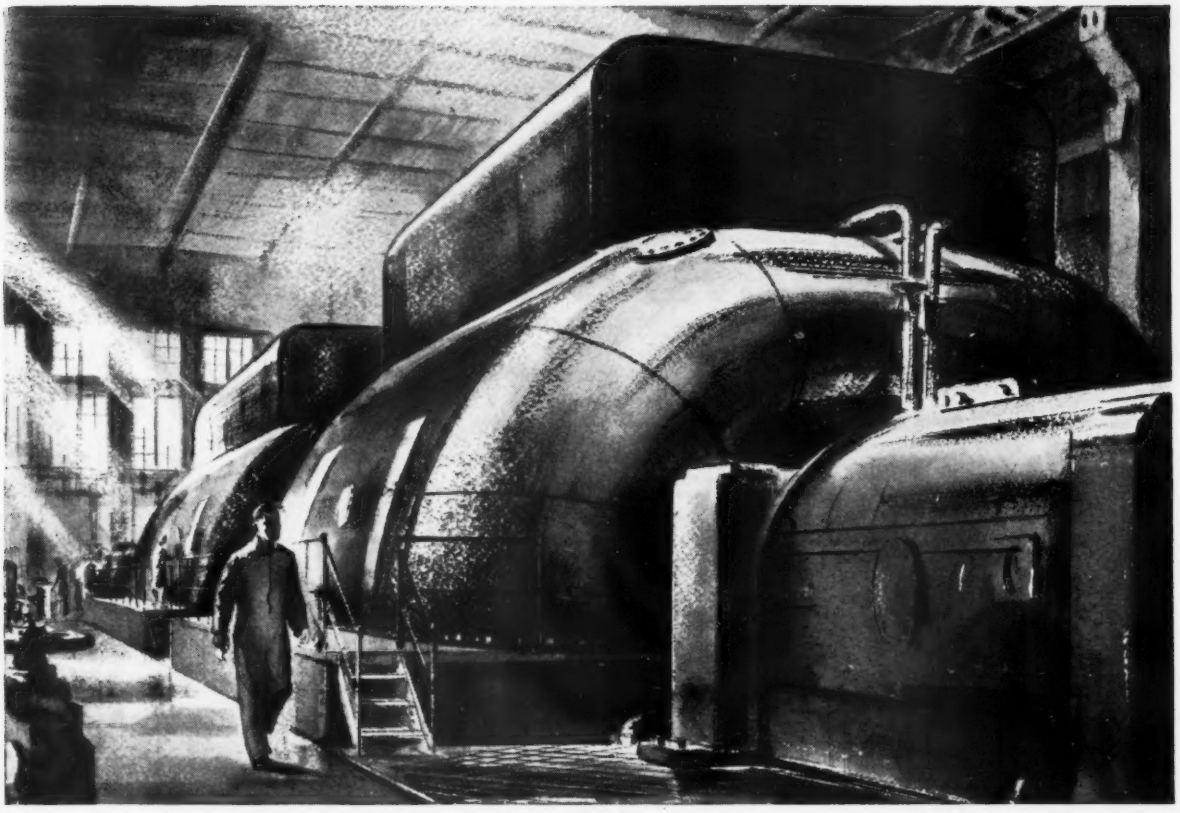
ALLOY STEELMAKERS · FORGEMASTERS · STEEL FOUNDERS · HEAVY ENGINEERS

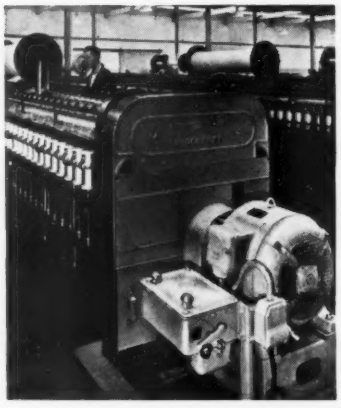
THOS FIRTH & JOHN BROWN LIMITED · SHEFFIELD · ENGLAND



The world's largest Generators will help to fill the demand for still more power

Progress in the development of nuclear energy for generating electricity is still making front-page news —and rightly so. Spectacular advances are continually being made. Less publicised, though in their own field no less outstanding, are recent developments in the design of "conventional" generating plant. The turbo-alternator illustrated, for instance, is a 550,000 kilowatt unit—twice the capacity of the next largest generator now on order for the Central Electricity Generating Board. This machine has been designed for the projected new power station at Thorpe Marsh. For Blythe 'B', another new station, 275,000 kilowatt in-line units are on order. These sets will be served by unit boilers and will operate at steam conditions of 2350 lb. per sq. in. and 1050°F, with reheat to 1000°F.

Nuclear power stations will play an increasingly important part in meeting the doubled demand for electricity forecast for the next ten years. Construction work is progressing rapidly at the sites of the Board's first three nuclear power stations, at Bradwell, Berkeley and Hinkley Point. The aggregate capacity of these stations will be not less than 1,100,000 kilowatts; and by 1966/7 some 5 to 6 million kilowatts of nuclear-generated electric power will be available.



Though these are projects which will not be completed for some time, the work of the Central Electricity Generating Board is playing an important part in today's fight against inflation. Power stations are being built now at an overall cost no greater than in 1948—£50 per kilowatt installed. And, alt'. ough the output capacity of the industry has doubled since 1948, the increase in manpower is only about one-third.

By providing today for the power we shall need in years to come, the Central Electricity Generating Board is building a secure foundation for our future prosperity.

THE CENTRAL ELECTRICITY GENERATING BOARD

CEGB

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SOLID GLASS
RADIATION SHIELDING WINDOWS
IN PRODUCTION
NOW

Measuring up to 4 ft. 6 inches x 3 ft. x 6 inches thick or up to 12 inches thick for slightly smaller sizes. Available now as polished glass blocks or as complete composite windows fully framed for insertion in the shielding wall. A range of densities is available in both stabilised and unstabilised glasses.

Our Technical Advisory and Design Service exists to help you solve your Radiation Shielding Window problems. Please write to us for full details.

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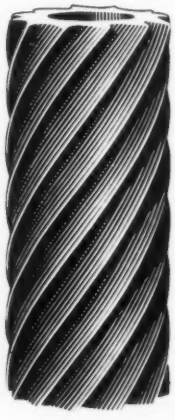
Pilkington Brothers Limited
St. Asaph · Flintshire

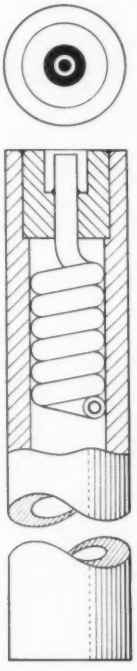
Some recent developments in manufacturing techniques and special applications of tubes in a variety of metals . . .

No. 6 OF A SERIES BY ACCLES & POLLOCK

This tubing is used in the manufacture of pencil sharpeners. It is made from special quality mild steel for case hardening, the diameter across the teeth being ·610″, and the bore ·312″.



High pressure orifice nipple made from stainless steel tube $\frac{1}{4}$″ o/d with a $\frac{5}{16}$″ bore, containing a stainless steel capillary coil made from $\frac{3}{32}$″ o/d x $\frac{1}{32}$″ i/d tubing.



Stainless steel flexible coupling. Inner tube is a flexible joint with a $\frac{1}{2}$″ bore, ·005″ thick.

Designers have a habit of asking for the impossible, but in a surprising number of cases Accles & Pollock produce an answer that enables the production people to translate the concept on the drawing-board into a physical, functional form. Accles & Pollock welcome all such opportunities to co-operate in developing new applications in the form of tubes and tubular sections.

Accles & Pollock

Accles & Pollock Limited · Oldbury · Birmingham · A Tube Investments Company

Makers and Manipulators of COLD DRAWN SEAMLESS and WELDED PRECISION TUBES in carbon and alloy steels, including stainless steel, and other metals

mw/220

$$\Pi = \sum_{i=1}^{n+1} a'_i \beta'_i \qquad \sum_{i=1}^{n+1} \beta i''$$

CONFERENCE NOTES

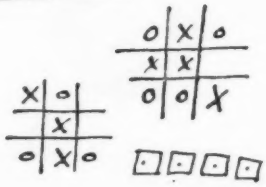
10 am : Possible energy source 100,000 curies (radio-caesium)

Heavy Water Reactor / 10-12 tons / 5 MWS 66. burnup — means 67,500 tons (C)

U·K·A·E·A

Walter 26428 Rockefeller

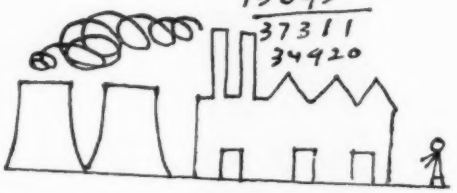
Lunch with Walter — 1230 — Astoria — Tell A.P

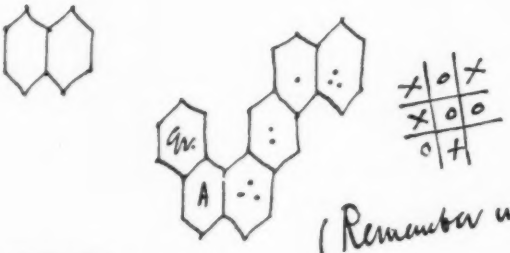


25% increased prod. Isotopes use in POLYMERISATION ?

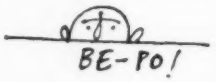
Gas/liquid cooled reactor (Gas mod.)

138
4365 | 6043618
4365
16826
13095
37311
34920





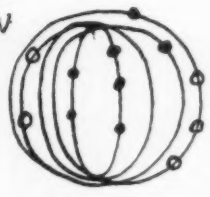
(Remember umbrella—Astoria)



BE-PO!

Walter again—dinner ?

Anticipated output 2000 MW in '65



U235
U238

see NEWALLS re. insulation of new installation

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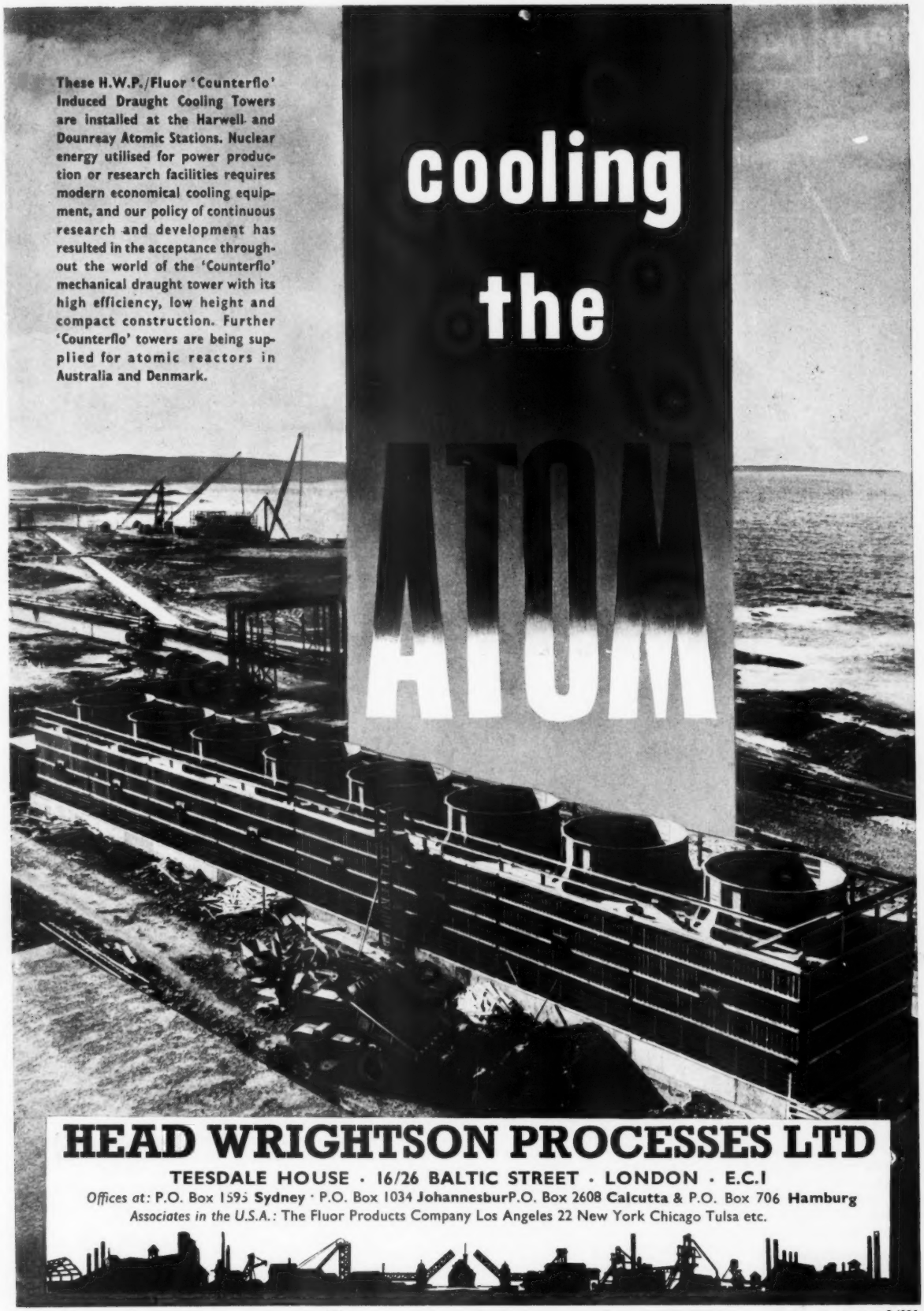
These H.W.P./Fluor 'Counterflo' Induced Draught Cooling Towers are installed at the Harwell and Dounreay Atomic Stations. Nuclear energy utilised for power production or research facilities requires modern economical cooling equipment, and our policy of continuous research and development has resulted in the acceptance throughout the world of the 'Counterflo' mechanical draught tower with its high efficiency, low height and compact construction. Further 'Counterflo' towers are being supplied for atomic reactors in Australia and Denmark.
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"Muraflux A" is the first of a new range of Murex granular fluxes for submerged-arc welding. It has been specially developed for the welding of mild steel by all machines using A.C. or D.C. for submerged-arc welding.

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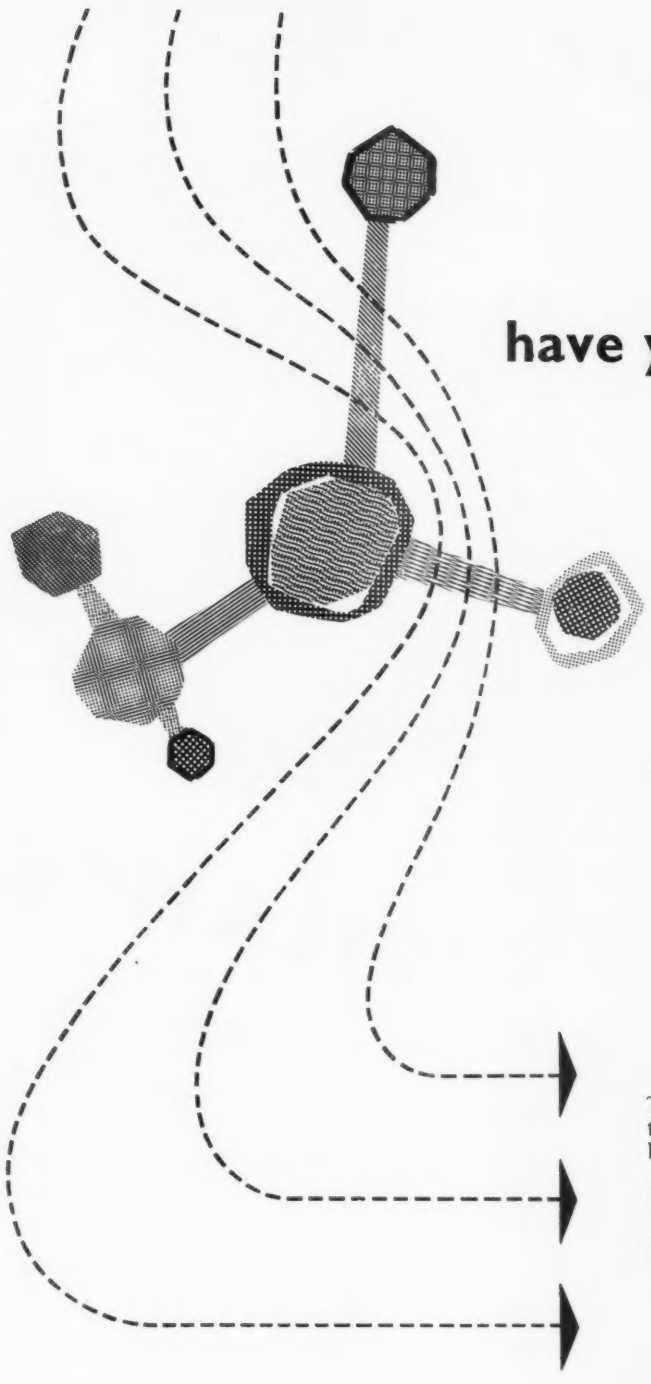

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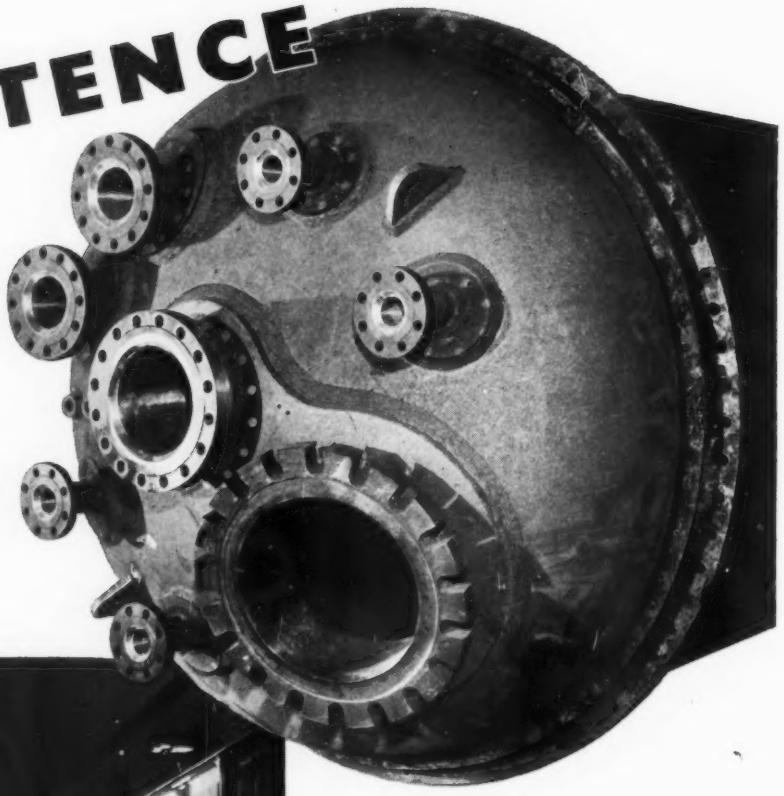

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Designed for a working pressure of 500 lb./sq. in.

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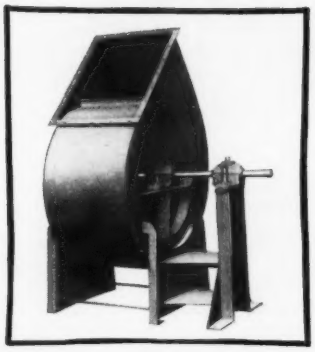
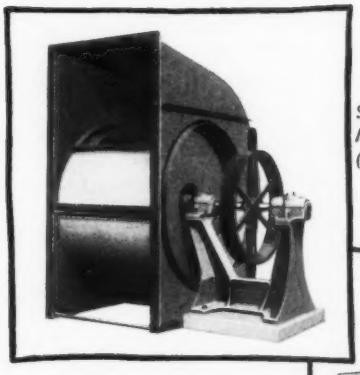
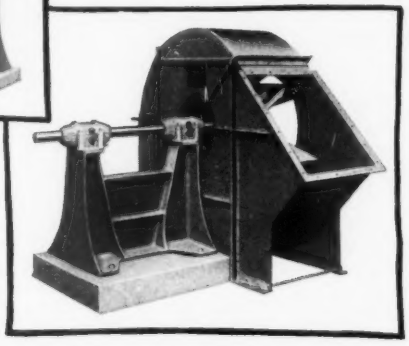


SLOW SPEED MULTIVANE FAN (Intermediate size)



SLOW SPEED MULTIVANE FAN (Large size).

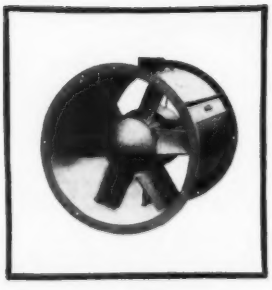
Air ways



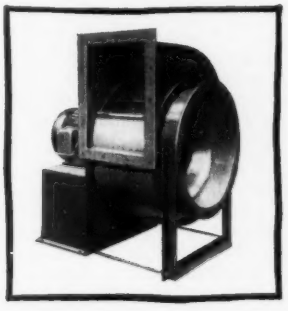
PADDLE BLADE FAN.

are

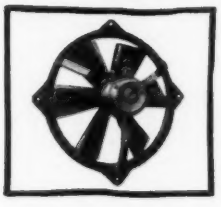
our ways



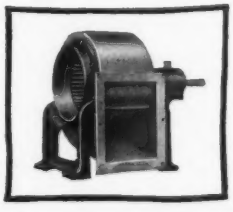
AXIAL FLOW FAN.



P.V.C. FAN



PROPELLER FAN.



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- ★ **TRACES radio-active material in chemical analytic processes.**
- ★ **MEASURES contamination of any resulting effluent.**

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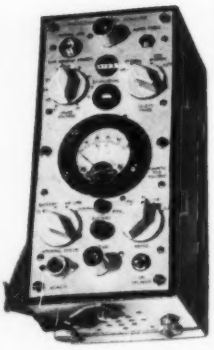
Write for descriptive leaflet No. 26D giving full details.



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- ★ **Transistorised, battery operated, portable.**
- ★ **Laboratory accuracy under field conditions.**
- ★ **Wide range of probes and accessories available.**

Airmec are proud to be the first to announce a fully transistorised monitor which combines laboratory accuracy with complete portability. The uses include :

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2. Checking atmosphere 'fall-out' and contamination of food, animals, crops, milk and water supplies, etc.
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4. Tracing the whereabouts of radio-active areas and making accurate assays of samples in geological surveys.
5. Tracing lost samples of radio-active materials both in buildings and out.

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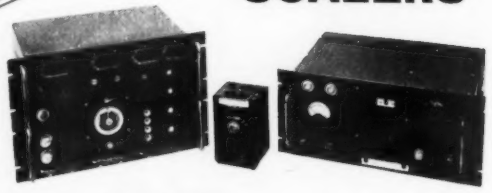
SCALERS



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- ★ **Provides comprehensive scaling facilities for all types of Geiger Scintillation Counters.**
- ★ **Incorporates stabilised E.H.T. supplies.**
- ★ **Fitted with automatic timing control.**

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Full details are given in descriptive leaflet No. 185

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(Main Contractors: Messrs. Constructors John Brown)

For their new 'ACRILAN' factory at Coleraine, N. Ireland, Messrs. Chemstrand have installed a 10,000 galls./hr. 'Boby' demineralisation plant for process and boiler feed water.

The plant comprises the following sections:

Coagulation and Settlement — Filtration — Cation Exchange — Weakly basic Anion Exchange — Degassing — Mixed Bed Ion Exchange.

2 VEITSILUOTO O/Y, Finland

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Established in 1875

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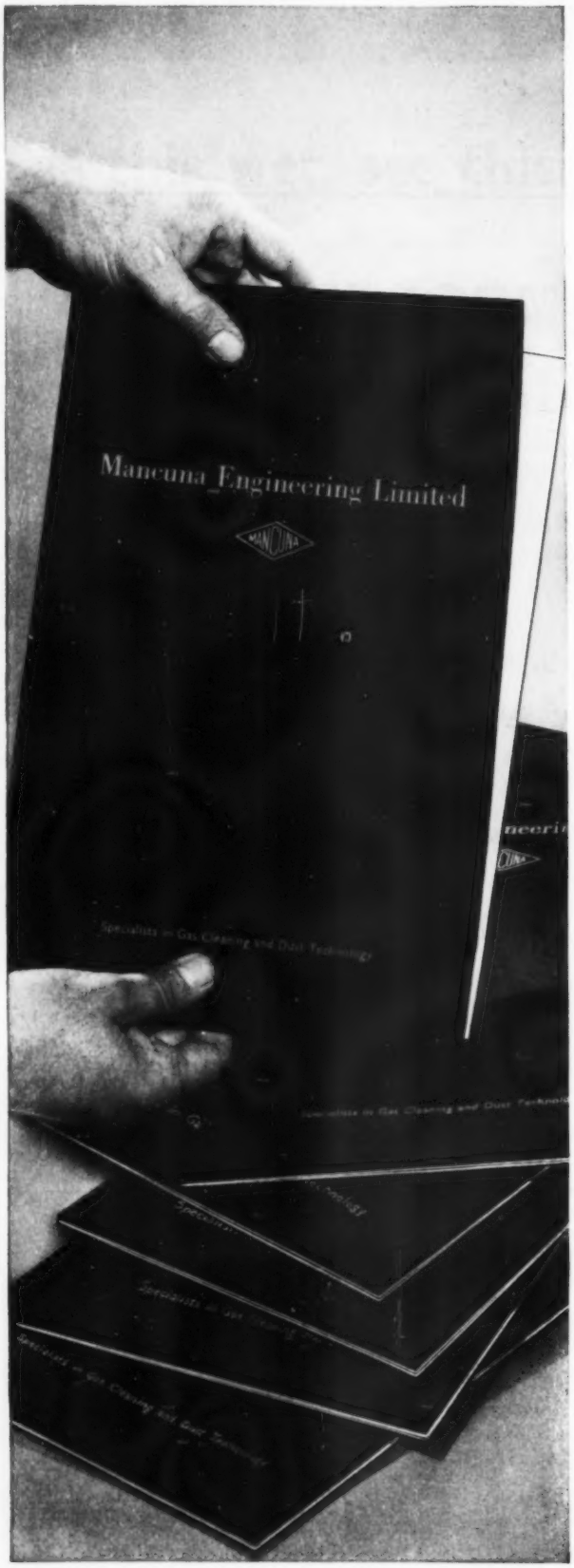

Memorandum on a dangerous subject

The creation of dusts infinitely more dangerous than anything previously known to mankind has given impetus to a 'new look' at the problems so far experienced, and the methods and equipment available to combat these problems. Mancuna Engineering Limited have been in the forefront of those few Companies who have recognised the exceptional nature of the demands which would have to be met in nuclear energy installations. Their latest memorandum describes the technical and scientific approach being applied to gas cleaning and dust collection and provides the nuclear energy engineer with an appreciation of the equipment available to him. *A brief request on your firm's letterhead will ensure you a copy.*

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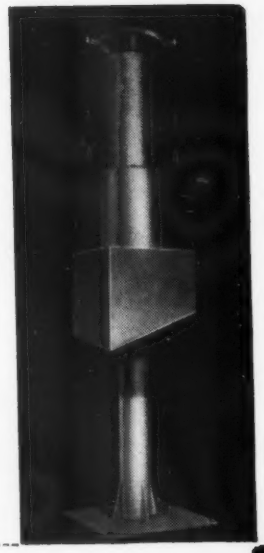
We are equipped with Weld X-Ray Plant, materials testing and microscopic examination facilities

ILLUSTRATED
(right) Hood Tube Assembly undergoing alignment and accuracy testing in the Butterfield workshops (far right) Component parts for Irradiation Tubes and Liners (below) Irradiation Hood Tubes and Liners during construction at the Power Station



AS FABRICATORS to the United Kingdom Atomic Energy Authority Butterfields are proud to have supplied Irradiation Hood Tubes and Liners for the **Chapelcross Atomic Power Station.** Butterfield craftsmen work to the high standards demanded by this very important work fabricating in Stainless Steel, Mild Steel, Aluminium, "Monel," Nickel etc.

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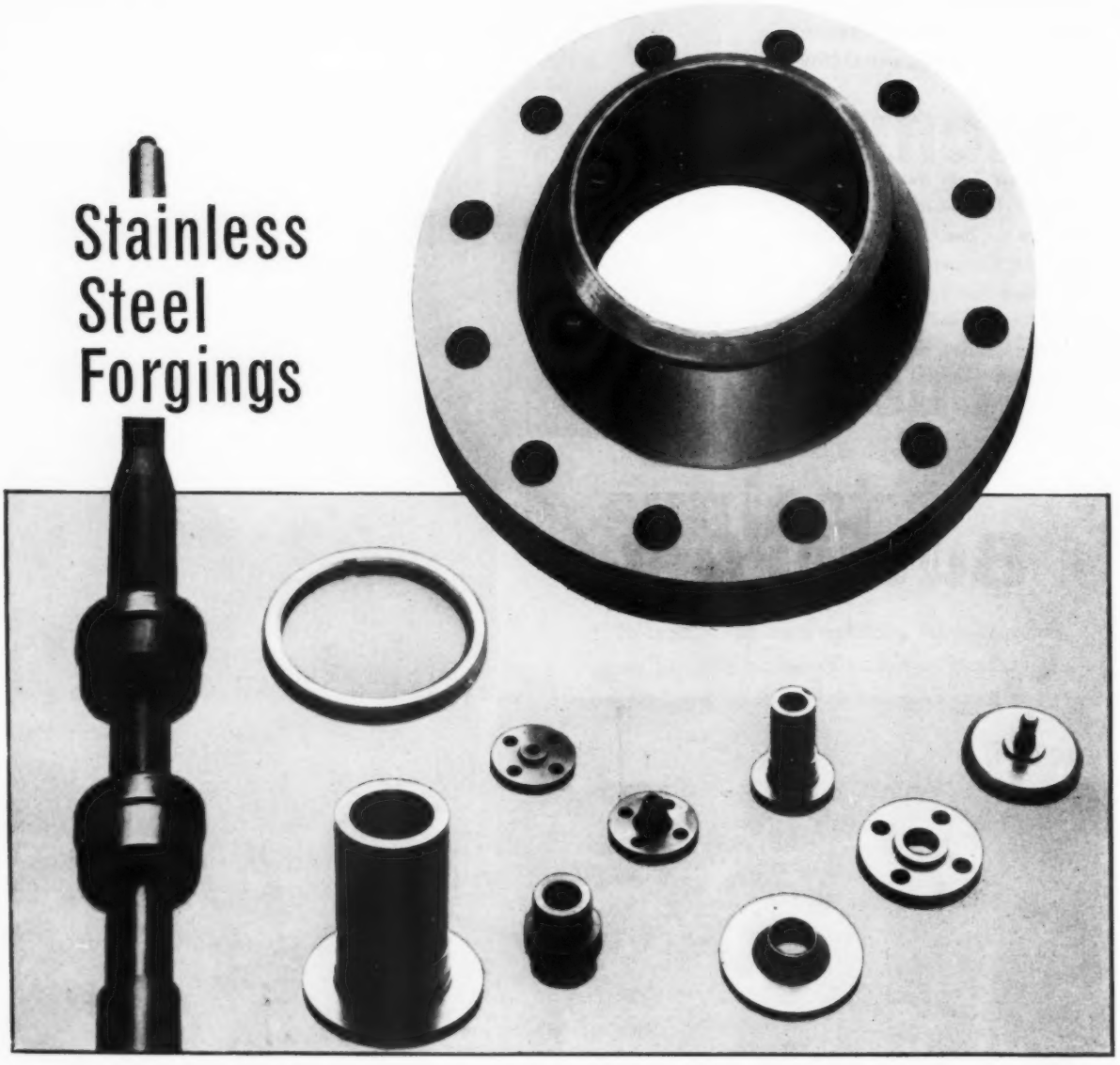
Stainless Steel Forgings



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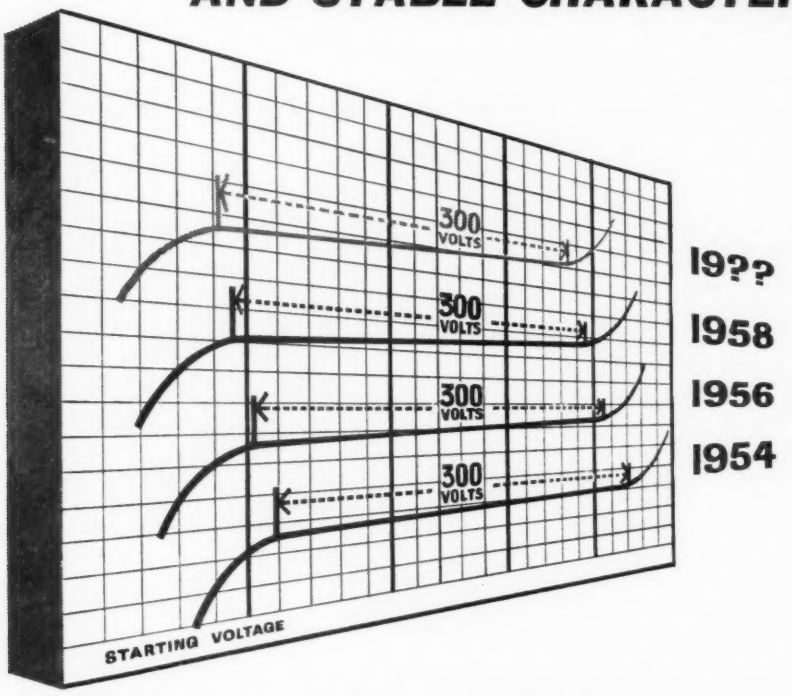
LONG LIFE

AND STABLE CHARACTERISTICS



Long life and stable characteristics under conditions of continuous or intermittent operation—these are the features that characterise all Mullard halogen quenched Geiger Müller Tubes.

These facts were verified by a test carried out on a tube selected at random. Operating intermittently over a few years, this tube has so far recorded a count of 4.8×10^{10}. During this period, its starting voltage has changed by only 20 volts and its plateau is still over 300 volts long (three times its specified minimum), with a slope of .03%.

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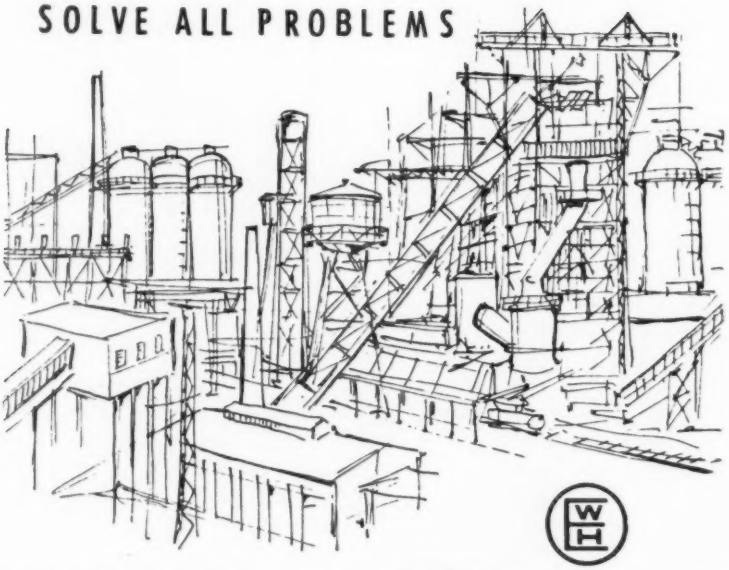

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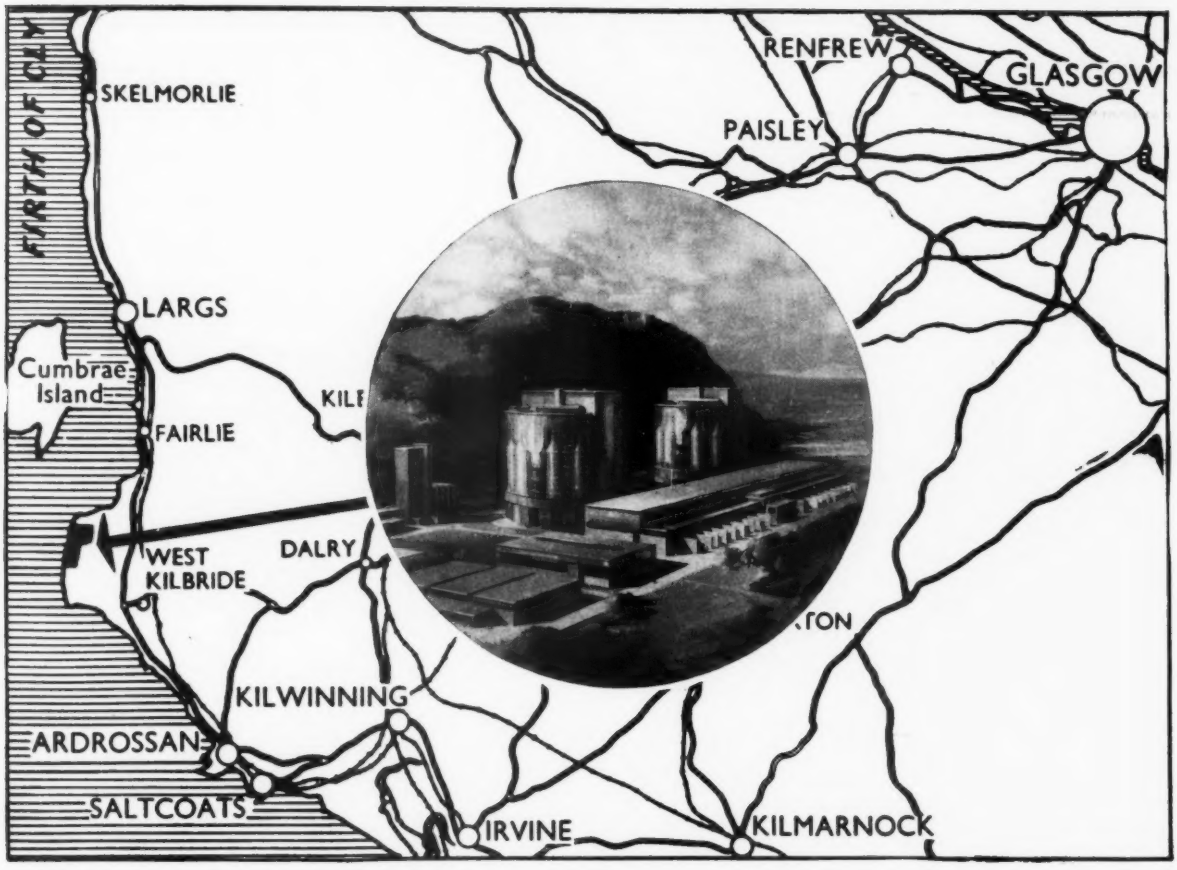

at Hunterston

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Simon-Carves Ltd

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NUCLEAR POWER DIVISION | Cheadle Heath, Stockport

IN ASSOCIATION WITH THE GENERAL ELECTRIC CO LTD OF ENGLAND

SC202

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Sealed Couplings by REMOTE CONTROL

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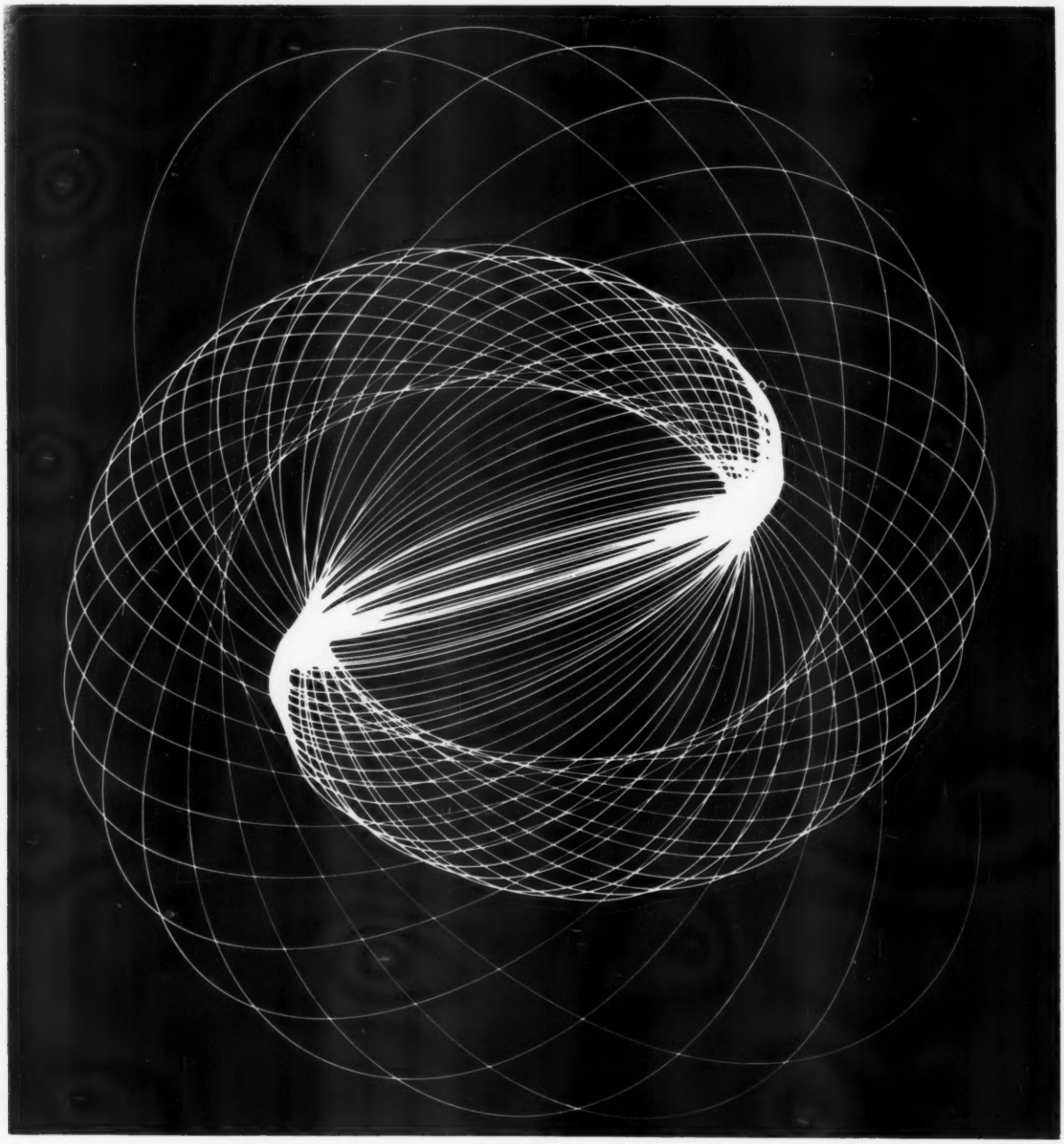

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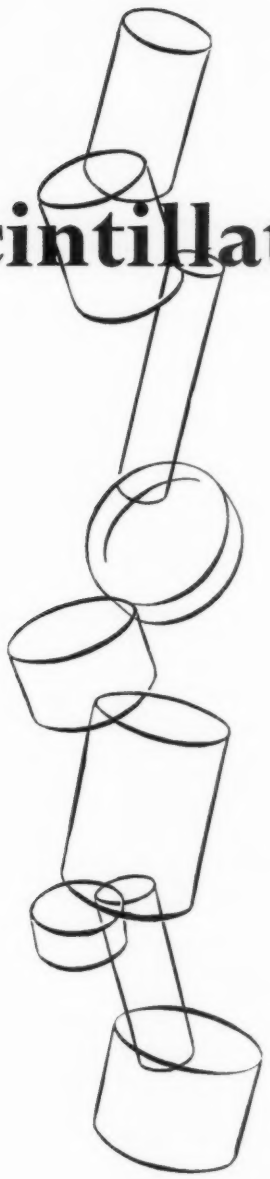
Scintillators in 5 forms



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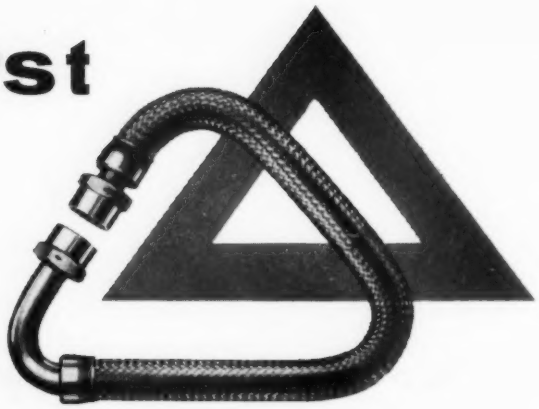
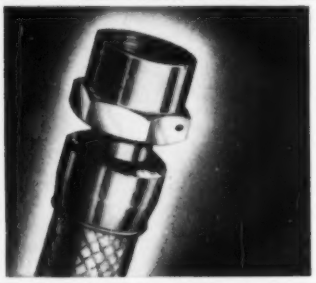
safety first



AVICA-FLEX

BELLOWS

(*including precision barometric units*, with closely controlled spring rate tolerances). For use in gas and fluid ducting systems for control of expansion or contraction, and to allow for misalignment. Other uses include shaft seals and glands. Available in stainless steel and other metals.



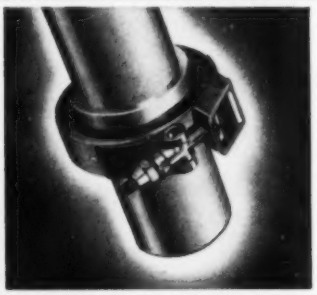
AVICA-FLEX

STAINLESS STEEL FLEXIBLE PIPE ASSEMBLIES

For conveying gases and corrosive fluids at temperatures from −196°C to as high as 450°C. Available from $\frac{1}{8}$" up to 4" diameter.

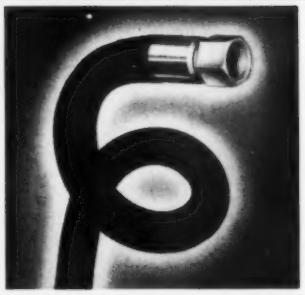
specify **AVICA** flexible assemblies and components

Where pressures or temperatures reach unusual extremes and vibration may be severe, take no chances—insist on AVICA pipe assemblies and components. Tested and proved by 20 years of service and used by the U.K.A.E.A. and throughout the nuclear engineering field, AVICA products are renowned for absolute dependability. Any problem of piping design or installation can safely be entrusted to Avica engineers.



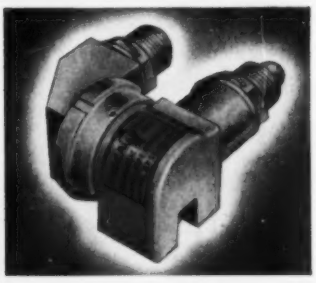
RIGID TUBE COUPLINGS

With mechanically attached V Flange or bolted flange connections. No welding. No brazing. Leak-proof. Pressure tight. Will withstand extremes of temperature and vibration.



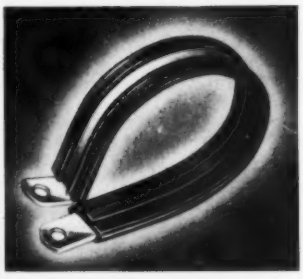
SYNTHETIC RUBBER FLEXIBLE PIPE ASSEMBLIES

Used to carry petrol, oil, air, steam, hydraulic fluids, for machine tools, hydraulic presses, mining equipment, at pressures up to 3,000 p.s.i. Size range $\frac{1}{4}$"—2". Temperature range −40°C to 160°C.



SWIVEL PIPE COUPLINGS

To provide rotary or angular movement in rigid or flexible pipe systems. In pipe sizes up to 1" for pressures up to 4,000 p.s.i.



SUPPORT CLAMPS

To hold piping and electrical cables. The rubber cushion absorbs vibration, can be renewed when worn or perished.

Illustrated leaflets describing the full range of AVICA products are available on request. Please write for those that interest you.

IGNITION HARNESS

Electrical wiring protected by rigid or flexible conduit from heat, oil, moisture and vibration.

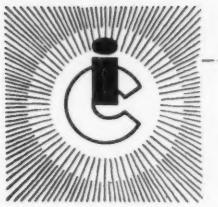
AVICA

A EQUIPMENT LIMITED

HEMEL HEMPSTEAD, HERTS

Cables: Avica Hemel Hempstead.

internuclear company



offers YOU Engineering Design and Consulting Services in the field of nuclear technology

Internuclear is an independent, staff-owned, private firm operating throughout the free world.

Internuclear has no manufacturing affiliations and is completely unbiased regarding the merits of any particular type of nuclear reactor and equipment manufactured anywhere in the world.

Internuclear Company's services include applications of British, French, Canadian and American Technology.

ENGINEERING STUDIES
DESIGN
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OPERATION

Nuclear Reactors of all types for:

Electric Power
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Process Heat
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- In ITALY .... Engineering and Consulting Services for SENN.
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- In U.S. .... Design studies for HALLAM NEBRASKA PROJECT.
- Nuclear Ship Propulsion.
  Preliminary design of gas-cooled nuclear reactor for General Motors Corporation.
- An Advanced Engineering Testing Reactor.
  Selection of concept and preliminary design to achieve thermal-neutron fluxes of 1.5×10^{15} in large irradiation loop facilities . . . for the U.S. Atomic Energy Commission.
- A high flux University Research Reactor.
  Selection of concept and preliminary design to give thermal-neutron flux of $> 3 \times 10^{14}$ in a 5 MW reactor.
- Special purpose reactors for heat and power.
  Development of reactor design concepts for use in chemical and pulp industries.
- Food irradiation reactors and facilities.
  Selection of concept and preliminary design for U.S. Atomic Energy Commission.
- Nuclear Propulsion of Aircraft, Missiles and Rockets.

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Clayton 5, Missouri

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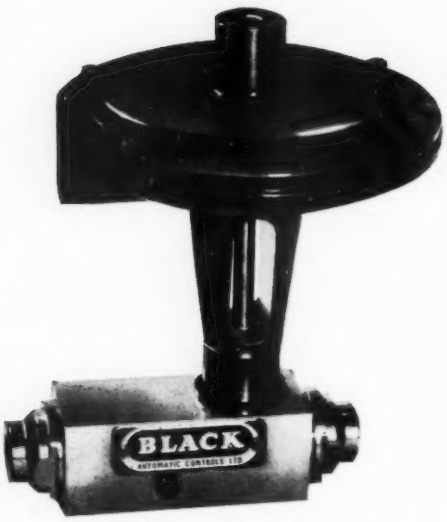
BLACK
AUTOMATIC CONTROLS LTD

CONTROL VALVES

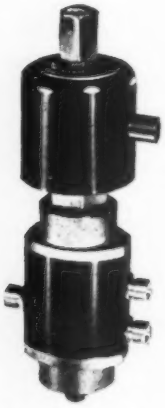
(Patents applied)

Steady development of solenoid and diaphragm-operated valves has produced a large number of models suitable for controlling gas and liquid media of many kinds.
Valves for general control applications (pneumatic and hydraulic) and highly specialised uses (nuclear energy and guided missiles) are also available in an increasing number of types to meet modern technical requirements, with particular reference to temperature and pressure.

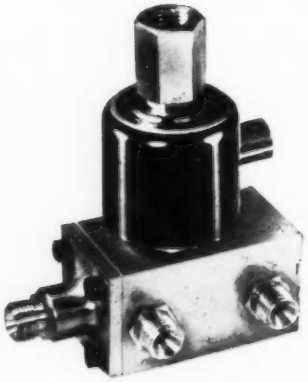


Diaphragm-operated lever valve. Added power gained by use of diaphragm and lever enables high viscosity fluids to be handled up to 10,000 psi. (DOLV)

Solenoid gas valves up to 6" BSP (threaded or flanged connection). (LG series)



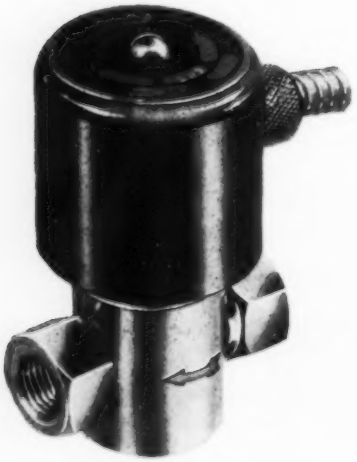
High-pressure 3-way valve up to 4000 psi for missile and machine tool applications. (TW/VHP)



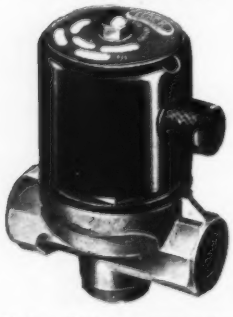
Miniature 4-way air valve for double acting power cylinders. (FW2)

OHV gas valve specially developed for controlling radiant gas heaters (in co-operation with Horstman Gear Co. Ltd.)

Miniature gas pilot valve. (LGM)



¼"–½" light duty gas, oil and air valves. (LG series)



Die-cast direct or reverse acting valve for gas cookers, etc. (AVG)

Solenoid-operated lever valve with reversible cage giving direct or reverse action at will. For high viscosity oils. (HDOL)

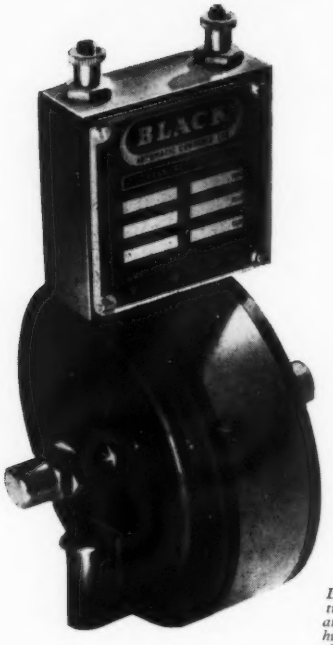
BLACK AUTOMATIC CONTROLS LTD
TELEPHONE: HAWTHORN 136

BLACK
AUTOMATIC CONTROLS LTD

PRESSURE SWITCHES

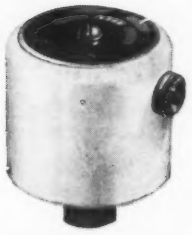
(Patents applied)

Characterised by small but robust switch action rated up to 5 amps, the Black range caters for pressure signalling and control functions for all kinds of industrial applications including missile and nuclear energy requirements.

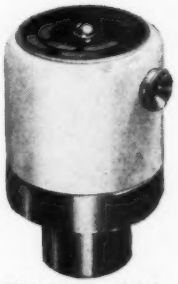


Differential pressure switch incorporating two diaphragms giving operation at very small differentials and very high pressures—fully adjustable. (DPS MkII)

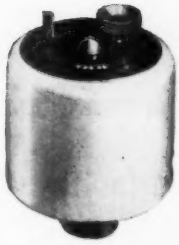
Fully adjustable flow switch to indicate flow failure up to ½". (FSW2)



Miniature fully adjustable pressure switch for air, oil, etc. up to 200 psi. (VPS/A)



High pressure switch for the range 200-10,000 psi, fully adjustable. (VHPS)



Miniature pressure switch for sequence operation, can be provided with up to six switches to operate at different pressures. (VPS/MU)

Low pressure switch 1"-30" wg (LPS). With adjustable differential (LPS/AD).

Flow switch for liquids up to 1". (FSW6)

Moving vane air-flow switch of very sensitive type for pressures up to 30" wg, fully adjustable. (AFS/MV)

We are dealing with an increasing volume of work for the aircraft industry, atomic energy applications and the like as well as producing standard valves in very large quantities. Please send full details of your application with your enquiry so that we can put forward suitable recommendations.

LEAFIELD CORSHAM WILTSHIRE

A.I.D. APPROVED

Have you a problem in remote handling?

If so, we can help you!

We have already been entrusted with the manufacture of the following equipment :-

Remote Control Machines for Element Handling

- ★ **REMOTELY CONTROLLED LATHES**— *For producing test pieces from enriched uranium elements.*
- ★ **X-RAY MACHINES & CASSETTE MECHANISMS**— *For X-raying irradiated fuel elements by remote means.*
- ★ **END REMOVAL AND STRIPPING MACHINES**— *For removal of the nose and tail units and stripping of the stainless steel Sheaths from the elements.*
- ★ **SEPARATION MACHINES**— *For separating the fuel elements from the breeder elements.*
- ★ **GENERAL-PURPOSE CUTTING MACHINES**— *For removal, by slitting, of the stainless steel Sheaths from the elements and for slicing up of uranium elements.*
- ★ **ELEMENT RECANNING MACHINES AND OPERATING GEAR**— *For recanning used uranium fuel for transport purposes.*

Machined Components and Assemblies

- ★ **CRUSHING PRESSES**— *50-ton presses for crushing uranium elements for subsequent test purposes.*
- ★ **ZINC BROMIDE VIEWING WINDOWS**— *For irradiated fuel element laboratories.*
- ★ **SERVICE SLEEVES**— *For manipulators, electrical and hydraulic controls.*
- ★ **COOLANT CHANNEL GAG ASSEMBLIES**

Having the most comprehensive engineering plant in the South, we can offer complete design and manufacturing facilities for all types of remote control equipment and precision machining of components and assemblies.

We thus take responsibility from inception, through design, manufacture and installation.

J. EVANS & SON (PORTSMOUTH) LTD
MARCYN WORKS - GOLDSMITH AVENUE
PORTSMOUTH

Tel.: 32233-6 (4 lines) **Grams: "Marcyn, Portsmouth"**

Pye Portable Wheatstone Bridge

- ✳ *Completely portable*
- ✳ *Built-in galvanometer and batteries*
- ✳ *Greater overall precision*
- ✳ *Fitted with the new 6001 switches*

Cat. No. 7383

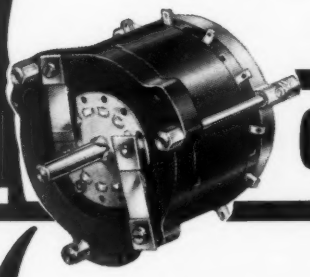
Total range 0.0001 to 1 megohm.
Series Arm comprises four decades in steps of hundreds, tens, units and tenths of ohms. Two Ratio Arms, 1, 10, 100 and 1000 ohms. Manganin coils.

Cat. No. 7384

Total range 0.001 to 10 megohms.
Series Arm comprises four decades in steps of thousands, hundreds, tens and units of ohms. Two Ratio Arms, 1, 10, 100, and 1000 ohms. Manganin coils.

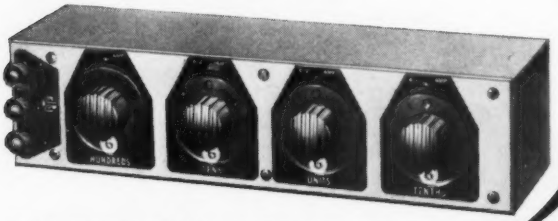
For measurement of extreme values of resistance connection can be made to an external battery and galvanometer. Extra terminals allow for the compensation of residual or lead resistances and such operations as the Varley Loop Test can also be carried out. The Series Arm decades can be used as a resistance box.

20,000,000. Operations



Pye Four Decade Resistance Box
Cat. Nos. 7640-7642

Novel presentation gives the reading in line, appropriate figures showing clearly against the contrasting background. The accuracy is $\pm 0.02\%$, except "tenths" decades which are $\pm 0.2\%$. Manganin coils are fitted. The decade box is constructed to have low thermal e.m.f. low-reactance winding and is mounted in a stove-enamelled grey-blue case: details of a.c. performance are given in a descriptive leaflet, available on request. Three models now in production.



- ✳ *Exceptionally low contact resistance*
- ✳ *Remarkable repeatability*

6001 PYE LOW RESISTANCE PRECISION INSTRUMENT SWITCH

- ✳ *Overall Switch Resistance: 0.7 m Ω*
- ✳ *Variation of Contact Resistance: ± 20 μΩ*
- ✳ *Contact Resistance Drift during life of switch: ± 50 μΩ*
- ✳ *Thermal e.m.f: 0.008 μV per degree Centigrade with uniform change of temperature*

During a life test the new Pye instrument switch completed 20 million operations, which is equivalent to some forty years of service. Yet the switch remained virtually unchanged—in fact, the stability improved within the rather narrow range specified! No maintenance was required and test conditions were more severe than usual.

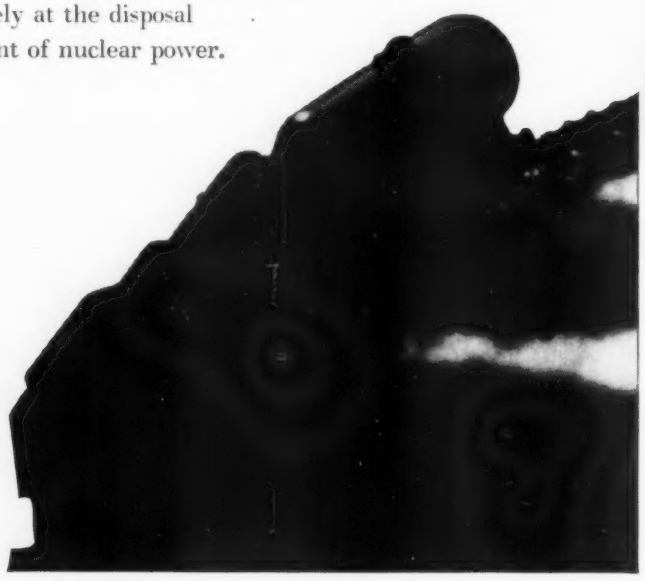
Send for full details of this switch and the instruments in which it is incorporated.

SCIENTIFIC PYE INSTRUMENTS

W. G. PYE & CO. LTD., GRANTA WORKS, NEWMARKET ROAD, CAMBRIDGE
Telephone: Cambridge 54411 Telegrams: Pye, Cambridge

Tick No 55 on reply card for further details

Jimmy will grow up and in due course
hand on—very reluctantly—his 00 gauge equipment.
But before his own son in turn becomes engrossed with model railways,
Jimmy himself will see great changes.
Ever-increasing outputs of electricity from atomic power stations
will transform the contemporary scene,
dispelling fog and domestic smoke
and bringing cleaner cities and brighter homes.
Manual workers and housewives alike
will benefit from more power at their elbows.
But before these things come to pass,
an enormous amount of exacting work remains to be done
—planning, designing, calculating and testing—
much of it breaking entirely fresh technical ground.
Talbot Stead's part in this great enterprise
is to make stainless and carbon steel tubes
in large quantities and to exact dimensions;
tubes made to standards of almost surgical cleanliness;
tubes manipulated to the closest specifications.
All this is work which Talbot Stead, both by tradition
and technical development, are eminently capable of doing.
They are specialists in the production and manipulation of tubes
and this specialised knowledge is freely at the disposal
of all concerned with the development of nuclear power.



TALBOT STEAD TUBE CO. LTD · GREEN LANE · WALSALL · A COMPANY

Talbot Stead TUBES FOR ATOMIC ENERGY

Talbot Stead have been awarded contracts to supply the following reactor components :—

BRADWELL NUCLEAR POWER STATION :

C. A. Parsons & Co. Ltd.: *Short Charge Plugs ; Absorber Rods ; Fuel Element Support Assemblies ; Control Rod Standpipe Plug Assemblies ; Control Rod Standpipes ; Charging Standpipes ; Neutron Source Assemblies; Control Rod Channel Gags; Control Rods.*
A. Reyrolle & Co. Ltd.: *Burst Slug Detector Tubing.*

BERKELEY NUCLEAR POWER STATION :

AEI John Thompson Nuclear Energy Co. Ltd.: *Control Rods ; Control Rod Guide Tubes.*

HUNTERSTON NUCLEAR POWER STATION :

The General Electric Co. Ltd.: *Control Rods ; Distance Tubes ; Charge/Discharge Tubes.*

HINCKLEY POINT NUCLEAR POWER STATION :

Atomic Power Projects Ltd.: *Restraint Assemblies.*
Matthew Hall & Co. Ltd.: *Burst Slug Detector Tubes.*

MANUFACTURERS OF: CARBON, ALLOY AND STAINLESS STEEL TUBES · BI-METAL TUBES · 'METICA' METAL CLAD CARBON AND GRAPHITE TUBES · 'METIOR' SANITARY PIPE FITTINGS MACHINED FLANGES AND COMPONENT PARTS · 'FORJEND' STAINLESS WELDING FITTINGS · CARBON, ALLOY AND STAINLESS DRAWN AND GROUND BARS AND WIRE

TSW/16

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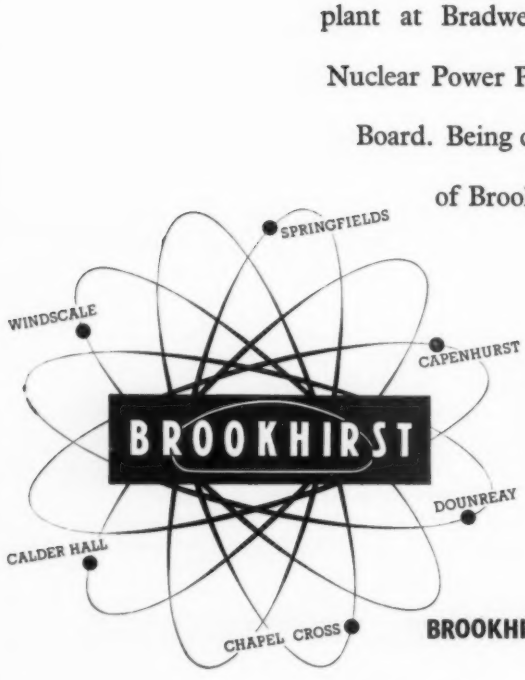
BROOKHIRST

for BRADWELL

Under sub-contract to A. Reyrolle & Co. Ltd., Brookhirst motor starters are being supplied for vitally important plant at Bradwell, the nuclear power station being built by the Nuclear Power Plant Co. Ltd., for the Central Electricity Generating Board. Being chosen for this notable installation is yet another proof of Brookhirst leadership in motor control in the nuclear field.



As specialised sub-contractors Brookhirst have also been called upon to supply very large quantities of motor control gear for the United Kingdom Atomic Energy Authority's establishments.

BROOKHIRST SWITCHGEAR LTD., NORTHGATE WORKS, CHESTER

A METAL INDUSTRIES GROUP COMPANY

CVS-58

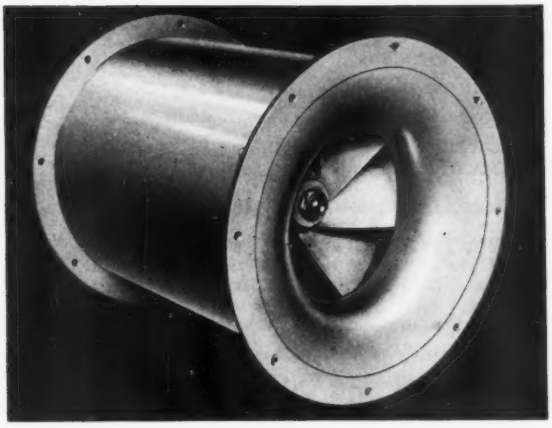
accent on

Research and Development

Evidence of the out-of-the-ordinary service that Keith Blackman render to industry and commerce in their need for fan engineering equipment is the accent placed on Research and Development. This exclusive service includes the use of laboratories specifically equipped for research into

axial and propeller fan design
centrifugal fan design
dust and air filtration
acoustics
metallurgy

now



The Ax-Cent Fan

A tangible result of the Keith Blackman service is the new AX-CENT COMPOUND FLOW FAN — Provisional Patent No. 3148/58. Externally similar to the conventional axial fan, the AX-CENT fan offers:

twice the pressure development
lower sound level & running speed
higher efficiency
centrifugal fan characteristics

Keith Blackman Ltd

MILL MEAD ROAD, LONDON N.17 TOTTENHAM 4522

Sales & Service Offices:

Birmingham, Bristol, Glasgow, Leeds, Leicester, London WC1, Manchester, Newcastle

T.A.1493/949

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Expressly designed

During the past twenty years,

ERMETO designers have developed an immense range of high pressure fittings to suit every conceivable need. If our range does not contain a fitting to suit your purpose do not hesitate to contact us. Our Technical staff will be pleased to collaborate in the development of any non-standard item.

Details of our standard range of high pressure couplings and valves are available on request.

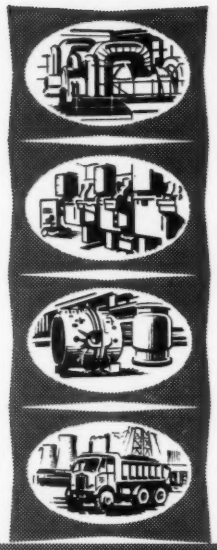
ERMETO

REGD. TRADE MARK

BRITISH ERMETO CORPORATION LTD

BEACON WORKS · HARGRAVE RD · MAIDENHEAD · BERKS · Tel: Maidenhead 5100 (10 lines)

These names make NUCLEAR POWER

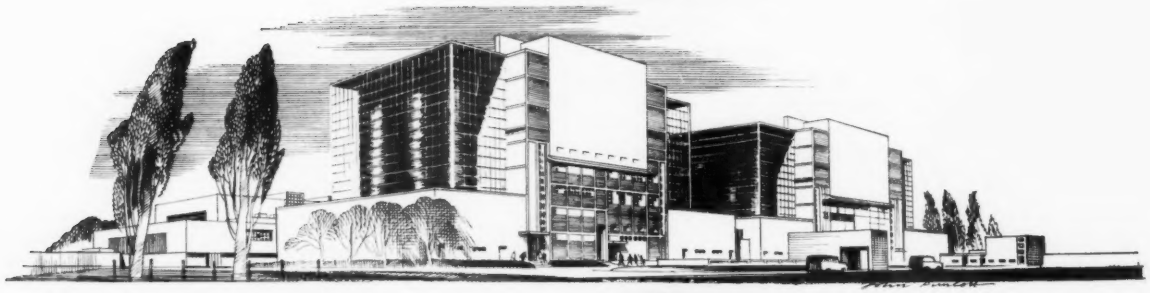


C. A. PARSONS & CO. LTD.

A. REYROLLE & CO. LTD.

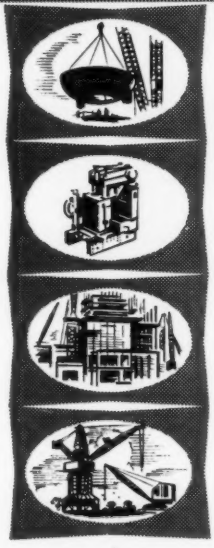
HEAD, WRIGHTSON & CO. LTD.

SIR ROBERT McALPINE & SONS LTD.



Bradwell, Essex, has leapt into fame as the site of the first commercial nuclear power station in the world to be built by N.P.P.C. Eight names make The Nuclear Power Plant Company Limited. N.P.P.C. thus combines the resources of eight specialist companies whose individual skills are co-ordinated to form a unified team capable of undertaking the construction of complete nuclear power stations throughout the world.

Bradwell nuclear power station will have a guaranteed output of 300 Megawatts. It is being built by The Nuclear Power Plant Co. Ltd. for the Central Electricity Generating Board.



WHESSOE LTD.

STRACHAN & HENSHAW LTD.

ALEX. FINDLAY & CO. LTD.

CLARKE, CHAPMAN & CO. LTD.

A Greater Britain through NPPC **Nuclear Power**

THE NUCLEAR POWER PLANT COMPANY LIMITED · BOOTHS HALL · KNUTSFORD · CHESHIRE

TGA NP3

Pressure increase Pressure relief

special-purpose

PUMPS and BURSTING DISCS

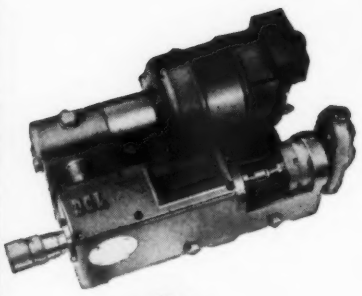
DCL DOUBLE-ACTING DIAPHRAGM PUMPS

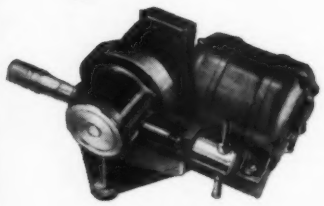
For handling condensed gases, including liquid carbon dioxide, at pressures above and temperatures below atmospheric.

Features include high volumetric efficiency, continuous operation without attention, and no liquid contact with glands.

4 standard capacity ranges from 0-250 lb./hr. to 0-2000 lb./hr. with delivery pressure up to 1200 p.s.i.

DIAPHRAGM PUMPS are also available for metering or transfer duties in a wide range of capacities.





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'M' PUMPS Accurate metering pumps suitable for most liquids; flow variations obtainable by micrometer adjustment of stroke.
10 capacity ranges from 0-0.75 litres/hr. to 0-37 litres/hr.

MICRO PUMPS For small constant flow adjustable by micrometer control of pump plunger stroke.
9 capacity ranges from 0-7 cc/hr. to 0-1500 cc/hr.

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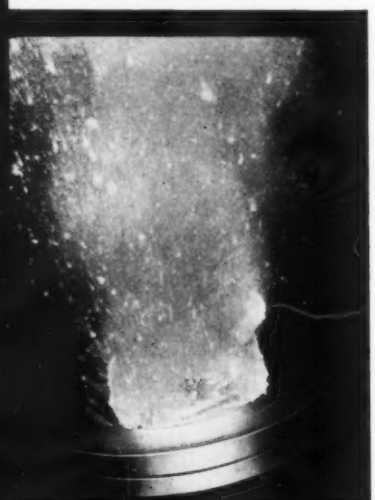

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For protection of pressure vessels in place of, or in conjunction with, relief valves. Creep tendencies at near-bursting pressures are overcome by hydraulically predoming D.C.L. discs, and vacuum supports can be fitted to prevent collapse due to external pressure. In addition to these patented D.C.L. features, there is a patented coding system that ensures that only the correct D.C.L. disc can be used, thus eliminating the danger of explosion due to the fitting of an incorrect disc.

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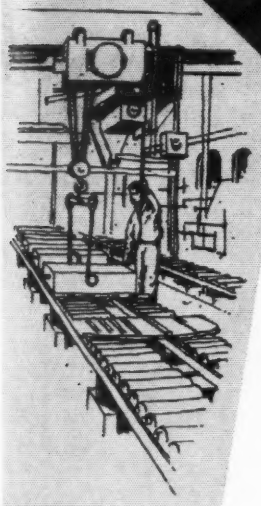
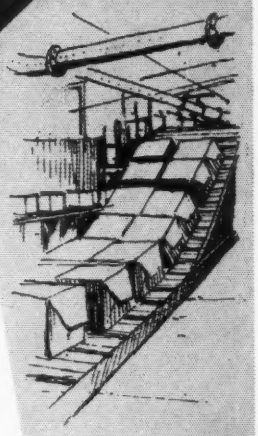




UNITED DIVISIONS

The united efforts of specialist engineering divisions concentrated upon particular aspects of mechanical handling, enable Paterson Hughes to plan and design integrated handling and production schemes specially suited to particular requirements. Large design and manufacturing resources, and first-class installation and maintenance service ensure that Paterson Hughes mechanical handling equipment gives complete and continued satisfaction. Engineers are always available to discuss your problems.

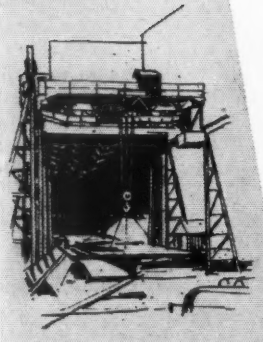
MECHANICAL HANDLING ENGINEERS & CRANE MAKERS

FOUNDRY DIVISION

The Foundry Division has long experience in the foundry industry. Many examples of Paterson Hughes pouring runways, conveyor systems, complete sand handling plants, cupola charging plants, casting cooling conveyors, are at work throughout the industry today.

INDUSTRIAL HANDLING DIVISION

Conveyor and elevator systems of all types for the handling of bulk materials, packaged goods and unit articles are undertaken for all industries. Paterson Hughes conveyor systems have ensured higher and smoother production flow in many well-known factories.



CRANE DIVISION

Paterson Hughes electric overhead travelling cranes up to 100 tons capacity are manufactured in the modern crane works in Glasgow. Competitive prices and exclusive design features have put Paterson Hughes cranes in the forefront of the industry.

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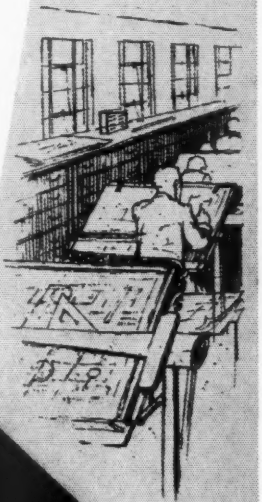

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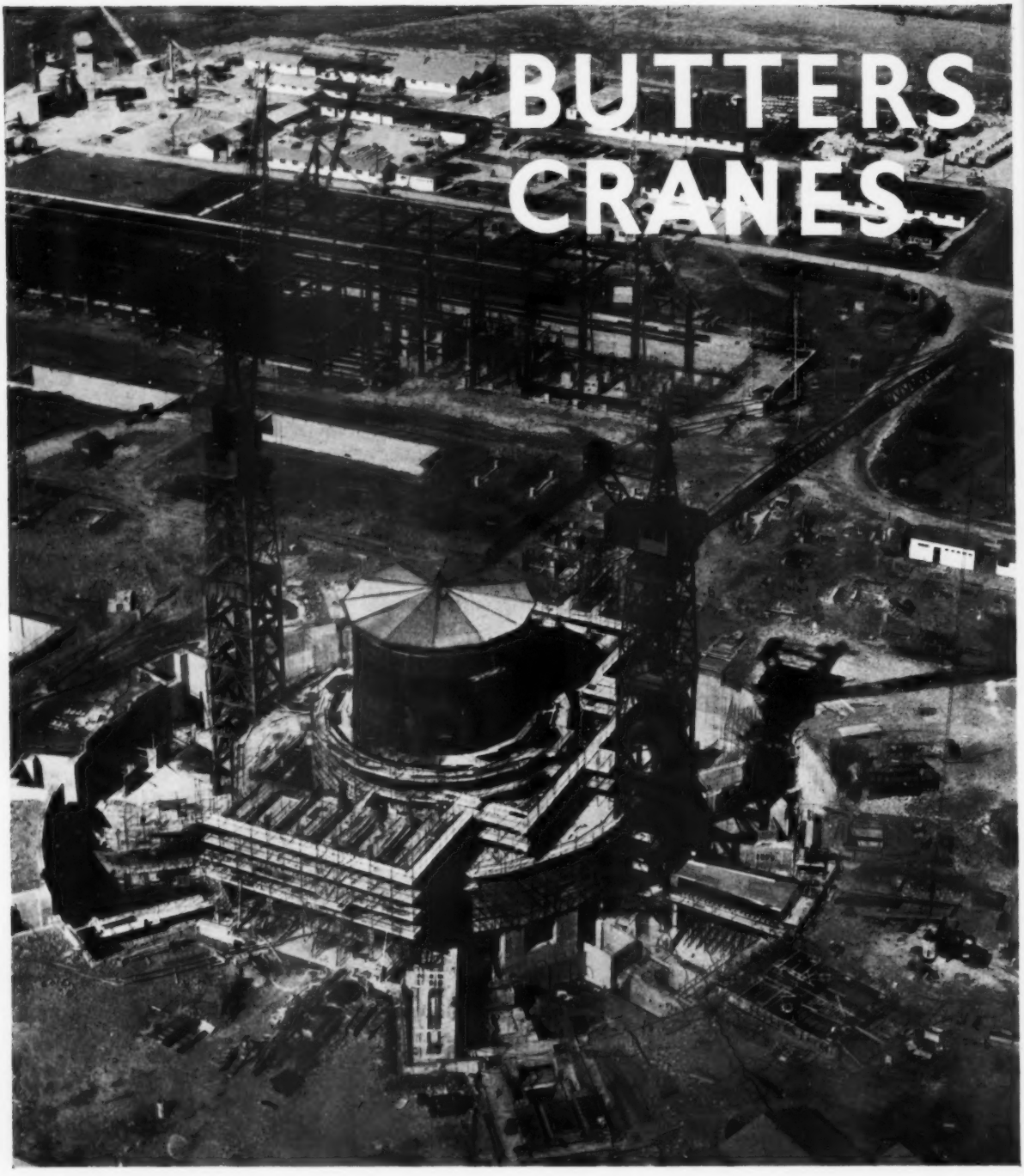

Monotowers at Berkeley

Butters Derricks were used, or are in use at Calder Hall, Chapelcross, Dounreay, Hinkley Point, Berkeley, Bradwell and Hunterston, that is—at all the nuclear power stations.

The photograph shows how excellently these cranes serve in the construction of tall erections. Four 15 ton models are in use in building the Reactors. Details are: Fixed type, electric, with 3 motors; 15 tons handled at 90 ft. radius, 6 tons at 125 ft.; Tower 120 ft. high; jib 127 ft. 6 ins. long.

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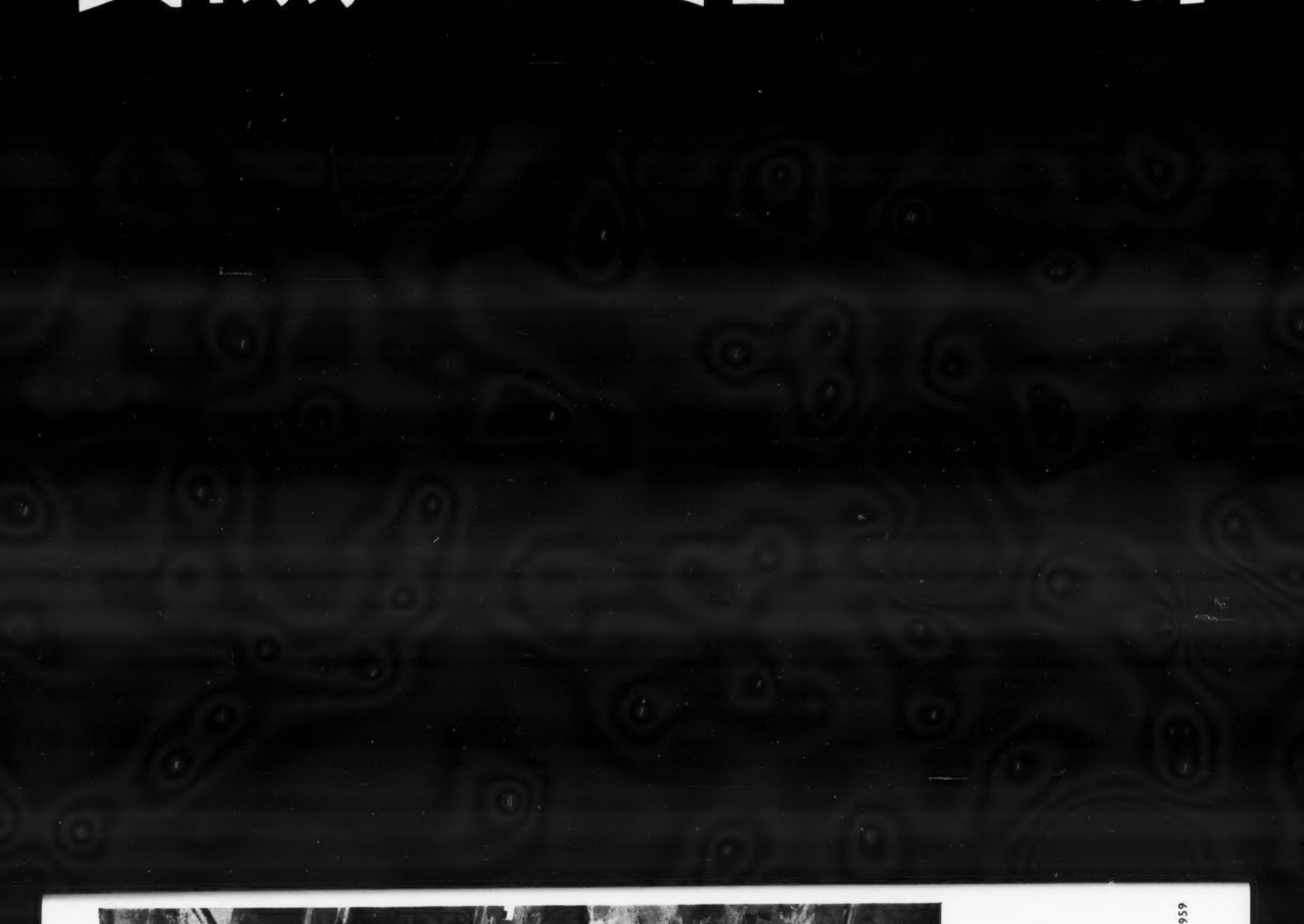

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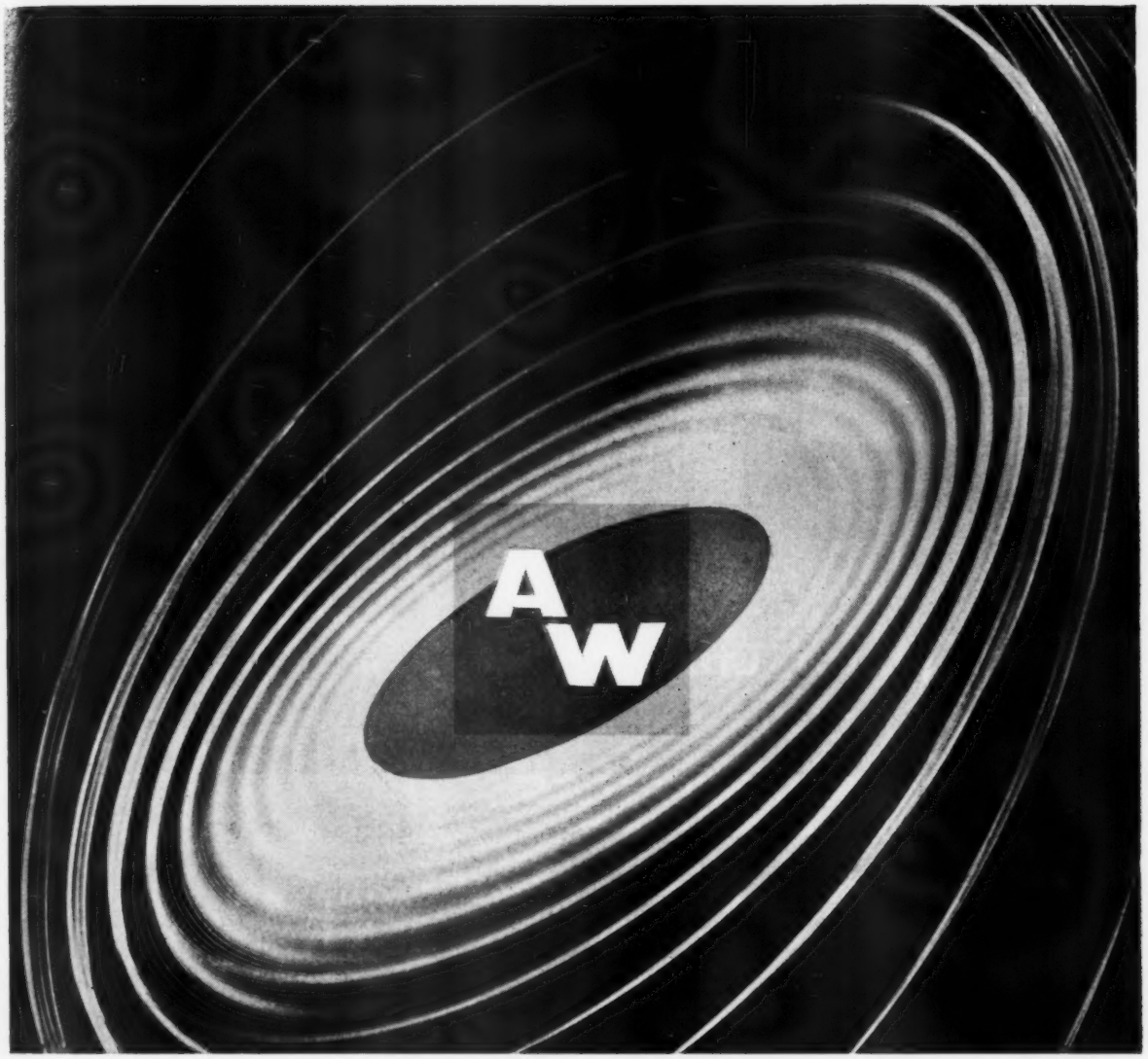

Scrutiny of youth

It is certainly the prerogative—and almost the duty—of each generation to question the ideas and loyalties of its predecessors. Were it not so progress would be slow indeed.

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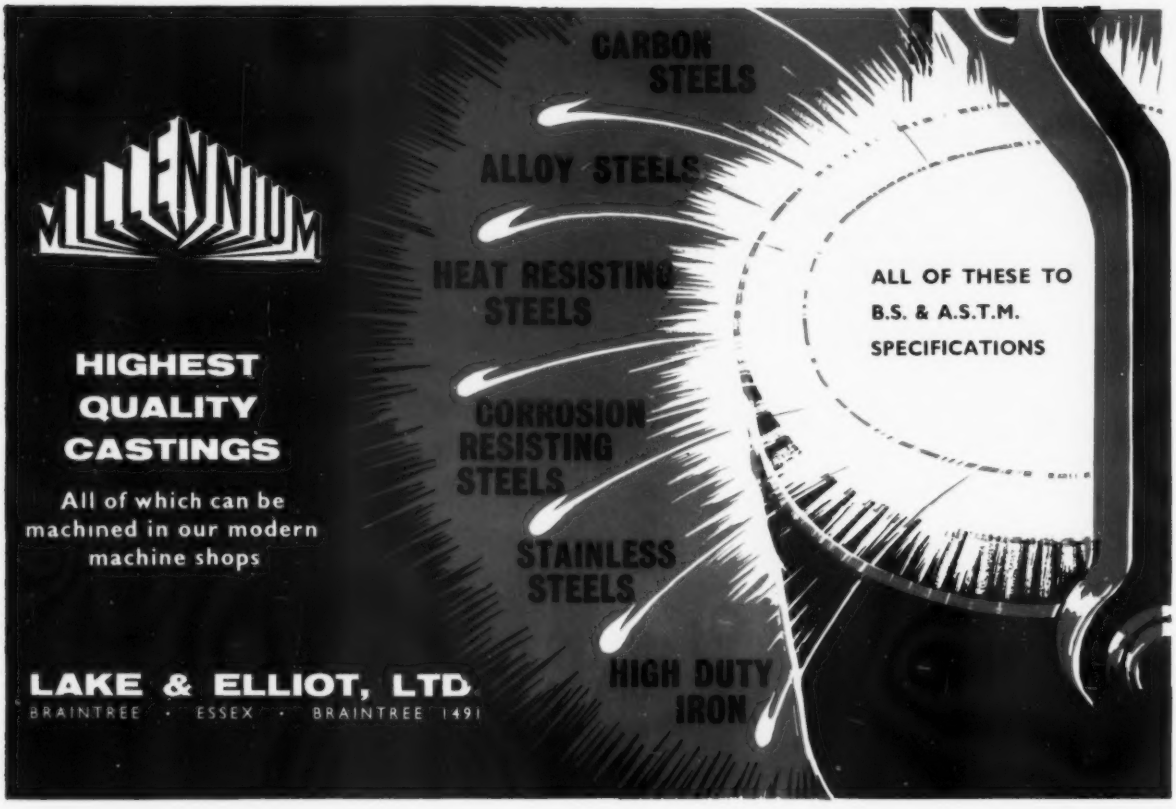
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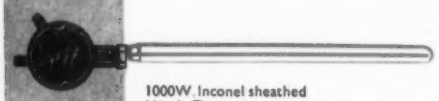

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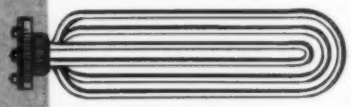

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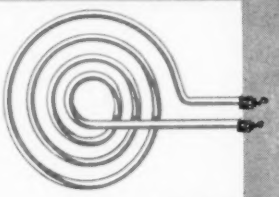

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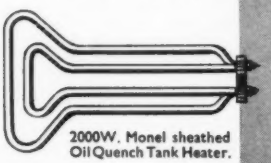

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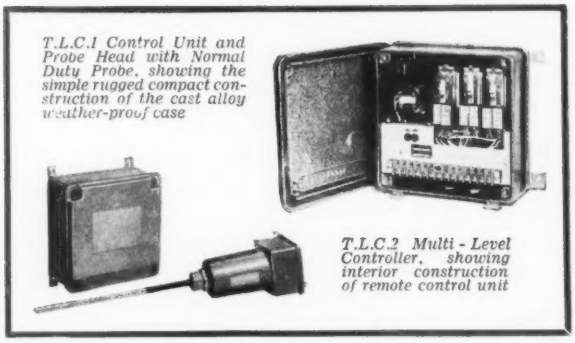

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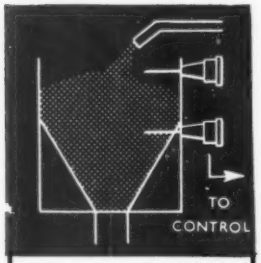
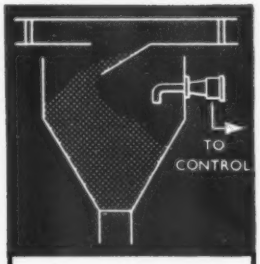
Unit in a sensitive form capable of operating for changes of capacitance of ± 2 pf.

Equipment range integrated by common probe head unit for all electrode assemblies for a comprehensive range of applications.



High and low level control of fertilizer in hopper. Control unit mounted remotely on central control panel



High level indication of flour in hoppers using angle probe

How it operates:

External capacitance represented by probe and earth is connected to the tuned circuit of the oscillator. The oscillator, and the relay in the control unit is energised when the probe is clear of material for high level, and when immersed for low level control. The control relay is operated by a transistor circuit which detects the changed conditions in the oscillator as a result of the capacitance changes at the probe on the approach or recession of the material.
The equipment is designed for operation on 200/250 volts or 110 volts, 50/60 c.p.s. single phase supplies, and imposes a load of 30vA approximately.

Some materials controlled by the T.L.C.

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How it is applied:

Illustrated are typical applications of the T.L.C.1 & 2 level controllers with examples of the many probe types available.

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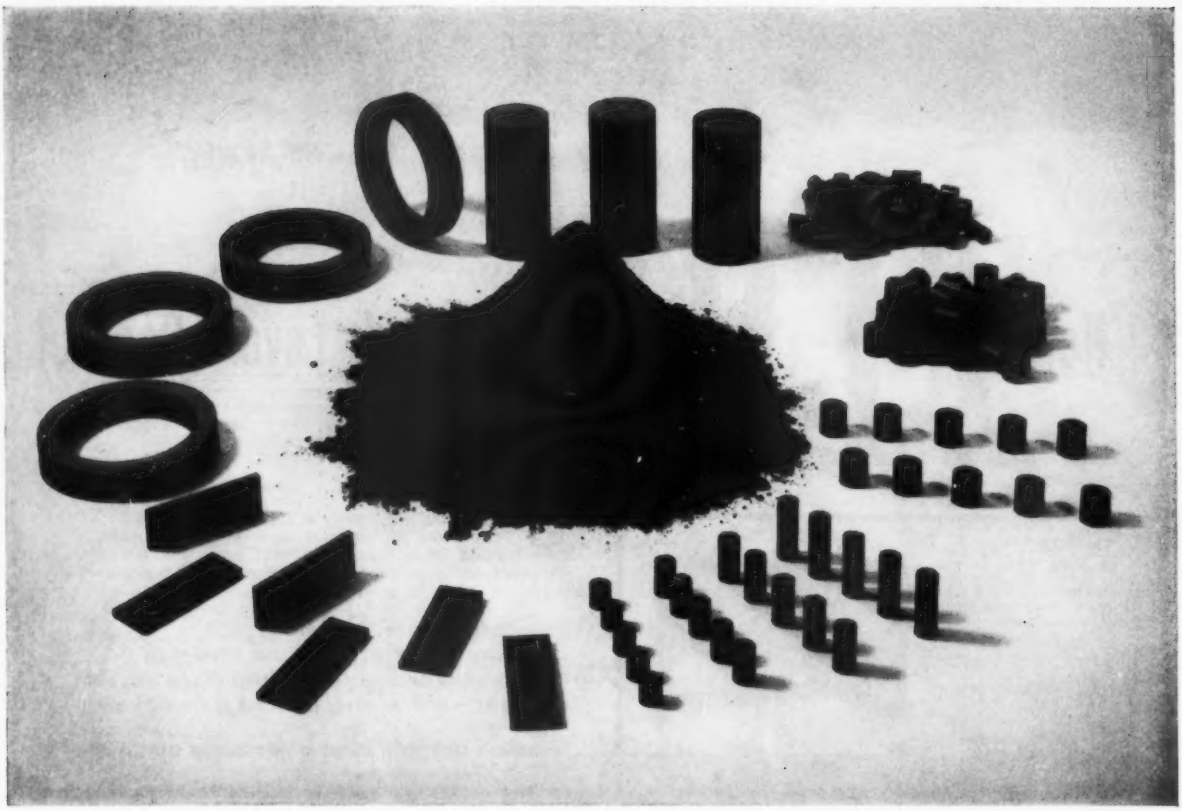

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In short, NUMEC has fully integrated chemical, ceramic, metallurgical and scrap recovery production and testing facilities—manned by personnel distinguished by their important contributions to reactor design and fabrication as well as to materials development and production.

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The UO_2 pellets shown at the right illustrate some of the difficult fabrication problems NUMEC has solved. As sintered, density is 94%; diameter .356" ± .002"; height .356" ± .010". Each pellet contains two thermocouple holes .032" in diameter. The edge of the outer hole is .030" from the periphery of the pellet.

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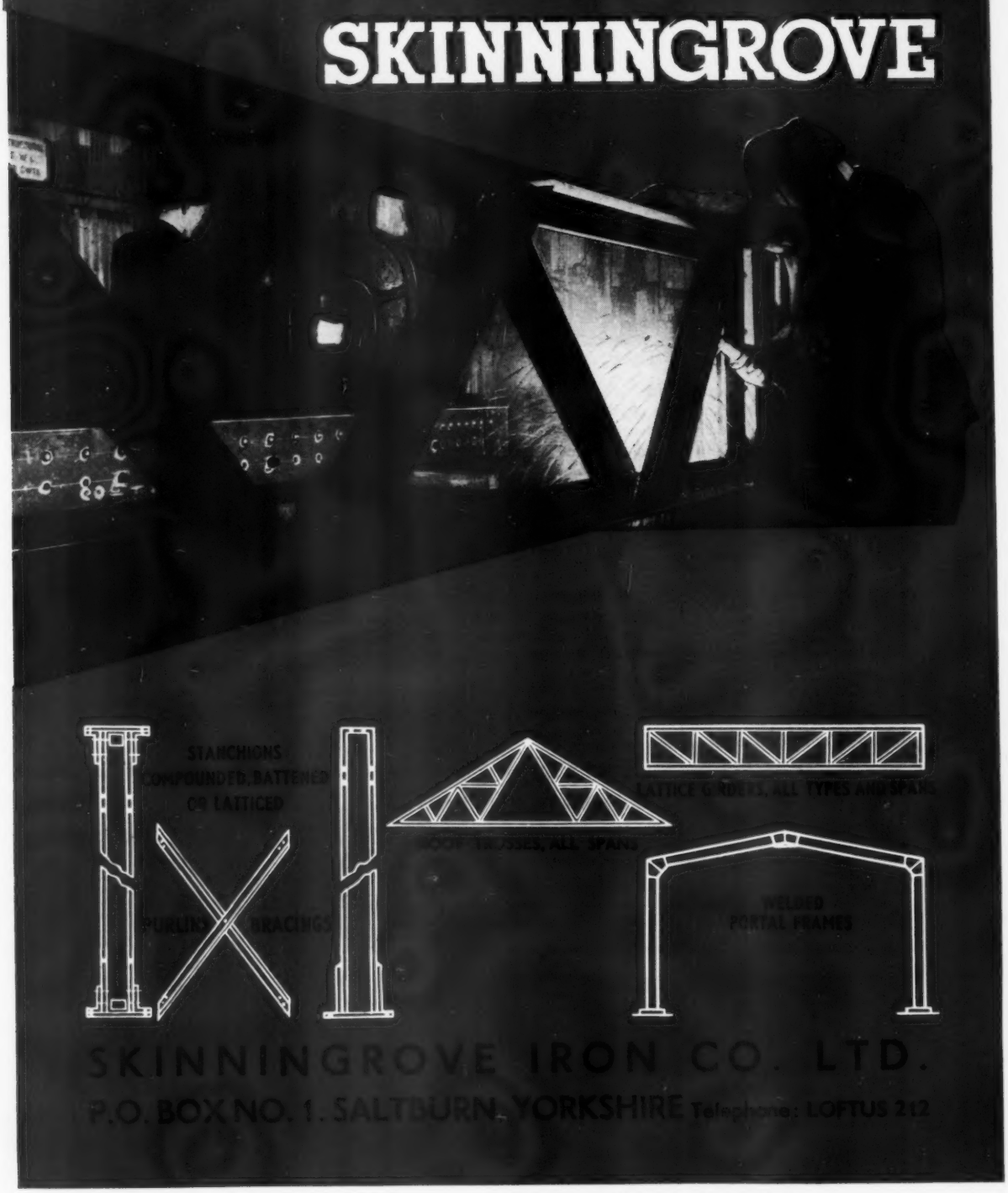
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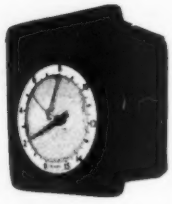

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To find out more about the Commander KE, write for Publication 352 *and* 993, *or telephone Atomic Energy Industry Contracts Dept. (Luton* 2440, *Ext.* 193) *for a quotation. Literature describing other KENT electronic equipment, such as amplifiers, servo motors, synchronous converters, is yours for the asking.*

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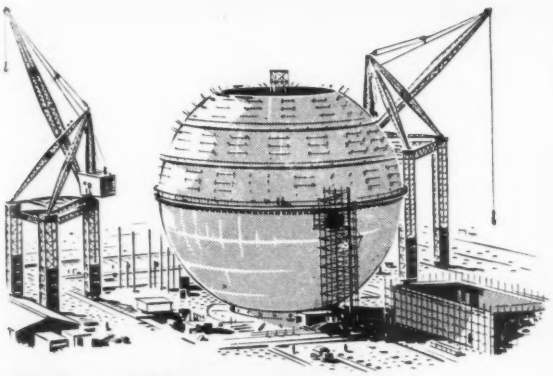

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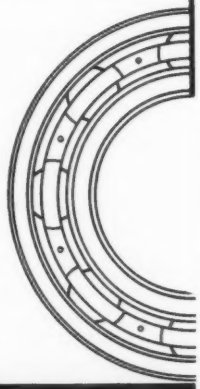

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Publishers Column

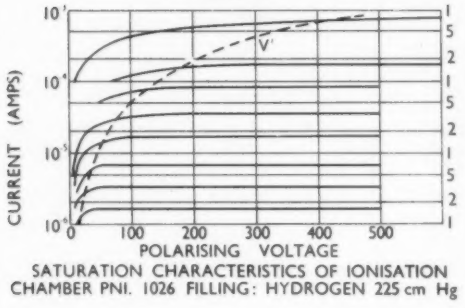
Cover Story

The cover is, of course, the very first thing you see when you look at a magazine. From the moment of NUCLEAR POWER'S birth nearly three years ago we have always sold this cover to an advertiser. Very often the advertisements have been excellently conceived and a real credit to the magazine.

But from this issue we have decided never again to sell to any firm the cover of NUCLEAR POWER. Our reasons for this decision are simple. Many periodicals, newspapers and books appearing in dozens of different languages and printed throughout the world regularly quote from NUCLEAR POWER or use it as a reference. Often in ignorance of the British publishing practice of printing advertisements on the front cover of magazines they gave the name of the firm appearing on the advertisement as the actual publisher! Unbelievable—but there it is. Sometimes advertisers have asked us to repeat an advertisement which had appeared on an earlier issue—the result of course was that two different issues looked exactly alike. Even more important, we feel, is the fact that the cover should convey something of what the issue contains. As each cover will be completely different readers can more quickly remember which number it was carried a particular article or piece of information. This naturally makes reference work just that bit easier.

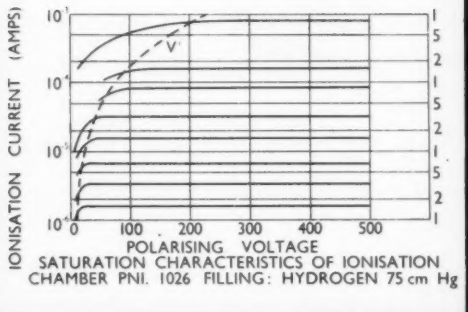
Designer of this first editorial cover is our own Gerry Withers. We think he has done a fine job of work.

Type PNI 1026



SATURATION CHARACTERISTICS OF IONISATION CHAMBER PNI. 1026 FILLING: HYDROGEN 225 cm Hg

Type PNI 1025



SATURATION CHARACTERISTICS OF IONISATION CHAMBER PNI. 1026 FILLING: HYDROGEN 75 cm Hg

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Neutron detectors for reactor control

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PNL 7

SIR!

LETTERS TO NUCLEAR POWER

ENSI—the facts

from Prof Carlo Matteini, President of SENN

SIR: In the December 1958 issue of NUCLEAR POWER, Mr J. Pettifer expresses some doubts relating to the economic side of the results of the IGE bid for the SENN nuclear power plant at Punta Fiume. It is not uncommon that economic comparisons lead to many different results which may confuse even the careful reader. This happens when the breakdown of costs or prices is not completely specified.

As the President of SENN, I would like to attempt to clarify the situation. The cost of the nuclear plant offered by IGE plus civil works amounts, in British currency, to £15,900,000, i.e. £106 per kW. The same costs for the British plants proposed ranged from a minimum of £20,000,000 (£133/kW) to a maximum of £26,500,000 (£177/kW).

If we consider all other expenses necessary to utilize our power plant completely and which must be taken into account for a thorough economic analysis—that is, spare parts, 100 km of 220 kV transmission lines, sub-station, overhead expenses, interests during construction, escalation clause and fuel fabrication cost (excluding cost of uranium)—we have an increase of about 40% which brings the figure up to £22,280,000 (39 milliard lire), which so greatly impressed Mr Pettifer.

Rome CARLO MATTEINI

Disasters—how many ?

SIR: Here is an interesting sidelight on the American philosophy concerning containment vessels for liquid-cooled reactors. In a recent issue of an American magazine, this phrase occurs in the editorial:

'. . . we tend to fall back on the security of overdesign rather than trust our engineering judgement to work closer to the limits. Thus we insist that our containment shells (which even under the worst circumstances would be taxed to their full design capability *only once or twice* during a lifetime) satisfy codes for pressure vessels that operate continuously under full load'.

An American designer sizes his containment sphere to withstand the shock of an explosion in which the primary circuit is ruptured and the whole of the coolant in the reactor flashes off into steam—the 'worst credible accident'. It is astonishing that anyone should contemplate the possibility of such a disaster occurring 'once or twice' during the life of the reactor. If it happened once the core would undoubtedly melt and it is unthinkable that the reactor could ever be rebuilt.

London ROBIN F. W. GUARD

Safety—green or red ?

from the Press Officer of the British Standards Institution

SIR: The jesting reference last month (December) in *Cross-Section* to BSI's 'climbdown', as you put it, over the use of a green cross in BS2929 to indicate first aid equipment, did not give an entirely accurate picture.

First, as many of your readers will know, in this British Standard—as in all others—BSI was acting as the servant of British industry and the green cross

continued on p 77

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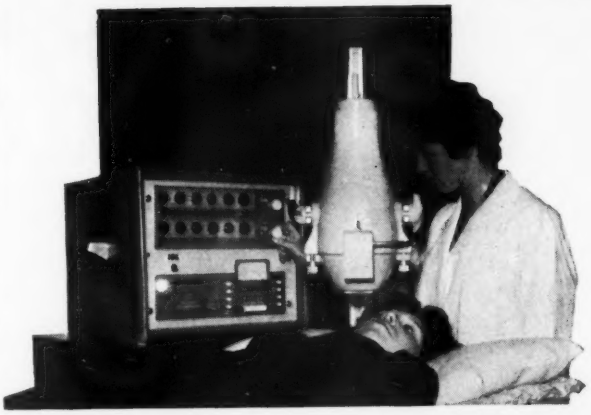

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BELGIUM: Nucleobel S.A., Monnaie Building, 28 rue du Fosse-aux-Loups, Brussels 1.

BURMA: Lawrence and Mayo (Burma) Limited, 81 Phayre Street, Rangoon.

CEYLON: Associated Instrument Manufacturers Limited, 140 1/5 Frumz Building, Front Street, Colombo. (P.O. Box 984.)

MALAYA: Associated Instrument Manufacturers Limited, 304R Orchard Road, Singapore 9.

PAKISTAN: Associated Instrument Manufacturers (Pakistan) Ltd., 3rd Floor, Muhammadi House, McLeod Road, Karachi. (P.O. Box 4800.)

CANADA: Dominion Electrohome Industries Limited, Technical Products Division, Kitchener, Ontario.

CHINA: Sino Trading Company Limited, 28 Chapel Street, Liverpool 3.

DENMARK: H. Struers Chemiske Laboratorium, Skindergade 38, Copenhagen K.

EGYPT: The General Company for Pharmaceuticals S.A.E., Branch AMON, 147, Mohamed Bey Farid Street, Cairo. (P.O. Box 600.)

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GERMANY: Sunvic Regler G.m.b.H., Friedrich-Ebert-Strasse 58, Solingen.

HOLLAND: R. S. Stokvis and Zonen N.V., Technische Afdeling, Postbus 426, Rotterdam.

INDIA: Jost's Engineering Company Limited, Head Office: Great Social Building (Post Box 243), Sir Phirozeshah Mehta Road, Bombay 1. Calcutta Branch: 19 British Indian Street (Post Box 64), Calcutta 1.

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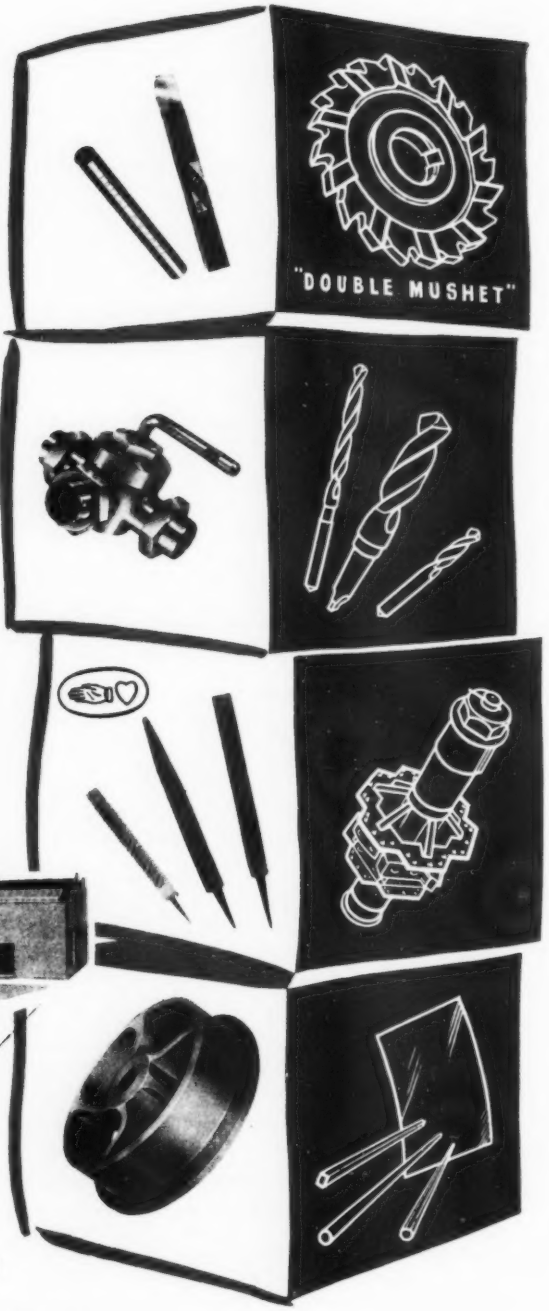

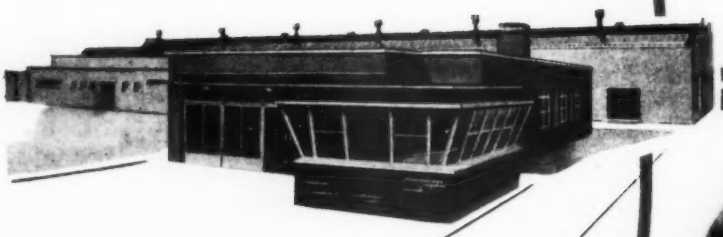

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SIR!

continued from p 75

recommendation was, in fact, agreed upon by a widely representative committee.

Second, one of the reasons why BSI would prefer to see the colour green associated with first aid equipment is that this is a growing practice internationally and it is obviously a good idea for safety standards to be on similar lines in as many countries as possible.

Third, the red cross is itself a registered trade mark, that of the British Red Cross Society, so that strictly speaking it should not be used by anyone other than the Red Cross.

Finally, may I just say that it was only several months after BS2929 was published—with attendant widespread publicity—that the difficulty over the green cross became apparent; the standard is now being revised in this one particular solely to ensure that we shall not infringe someone else's copyright.

London C. DOUGLAS WOODWARD

Stretch—a counterblast

SIR: In his article 'Is Britain on the right track' (*December*) K. L. Stretch uses a question for a title, begins with a question, continues to ask questions but provides answers only where these can be presented as extremes with his own opinions offered as a compromise.

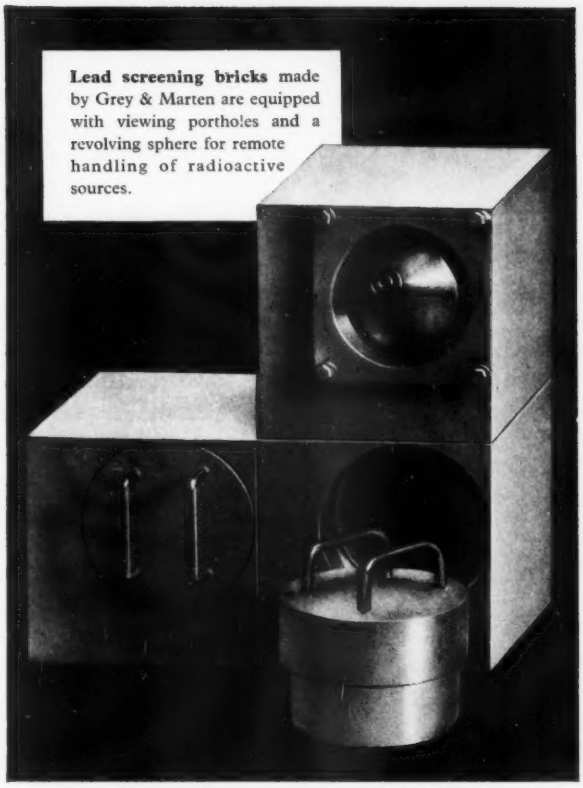
It would of course be extremely rash for this country to rush into building a large number of obsolescent nuclear stations, and a study of the projected programme shows that there is no intention of doing so. The obsolete Windscale piles are closed. The Mk I nuclear stations are being built to take advantage of current operational experience at Calder Hall, and CEGB staff are being, and will be trained, at Calder Hall; so the new stations should come on load with the most up-to-date operational technology at their disposal.

Operational experience must lag behind and depend upon the drawing office and laboratory because it is only here that long term trends can be accurately forecast and answers found to problems before they arise. Perhaps it is more important to have a man capable of understanding the whole organization rather than just the whole plant, in order that he may use the thousands of specialists at his disposal, including specialists in the 'clear analysis of what has happened in the light of the design criteria' and the 'rapid and accurate feedback of operational experience'.

In discussing instrumentation, Mr Stretch's stay at Calder Hall may not have been sufficiently long for him to realize the full potential of measurement, data processing, and up-to-date control technology as applied to the study of plant characteristics by frequency analysis methods. These are the tools used for 'clear analysis' and 'rapid and accurate feedback' in processes whose characteristics are not fully understood.

The Fleck recommendations whatever they were based on, were not based on the fallacy that the control of nuclear stations can be broken into a series of unit processes. It is a fact that nuclear stations have been successfully controlled in this manner, mainly because of the necessity of compartmentation for security.

Whitehaven COMPO



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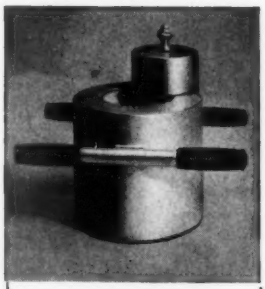

Storage pot typical of those used in standard safes not already fitted with lead protection, affords economical storage for radio-active material.

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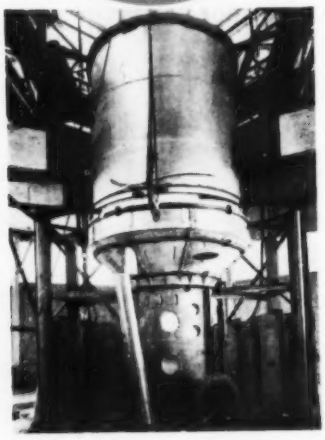

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This design for a 500 MW nuclear power station is more than a mere 'artist's impression'. It is based on a fully costed specification, and could be started tomorrow.

The 5 MW research reactor, MERLIN, exists already—in triplicate. This is as near being a 'production model' as the industry has yet achieved.

Between these extremes, the Berkeley power station, planned to generate 275 MW, is taking shape.

With more than their share of the world's experience in this new industry—with the backing of such mighty firms as BTH, Metropolitan-Vickers and John Thompson—and with a range of models that would not disgrace a *couturier*, the AEI-John Thompson Company feels no immodesty in crying its wares.

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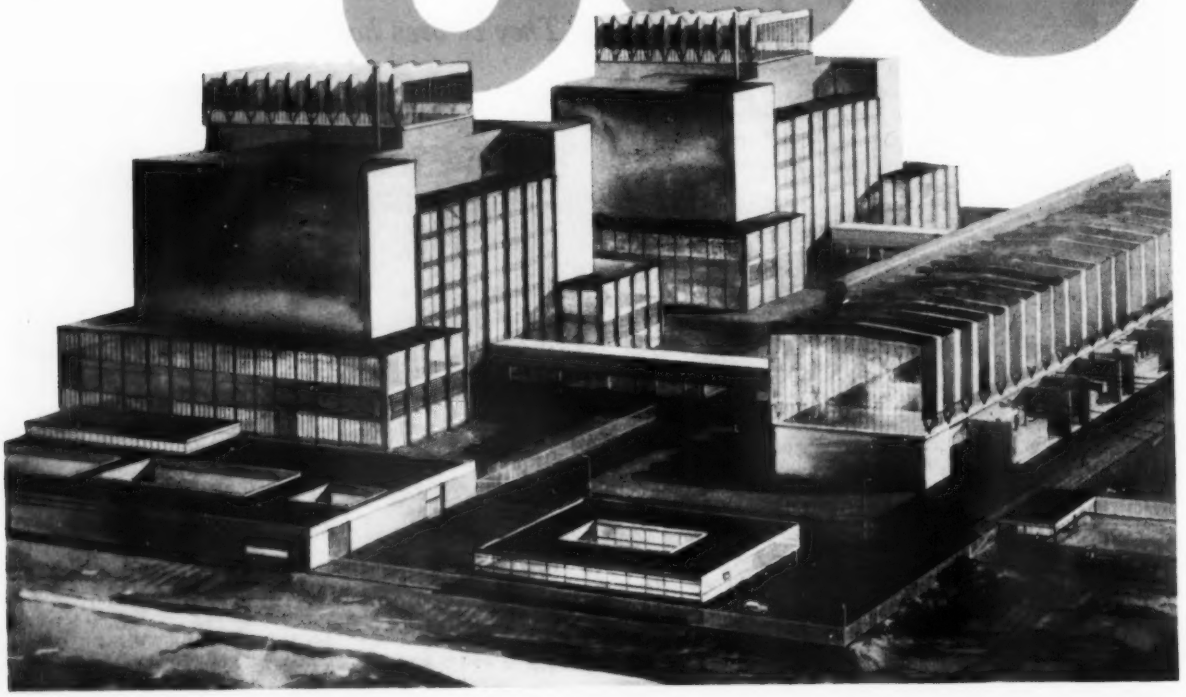

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Nuclear Power
REACTORS MATERIALS INSTRUMENTATION PROCESSES IRRADIATION
JANUARY 1959 VOLUME 4 NUMBER 33

1959 in prospect

The year that has just passed has not been conspicuous for the number of new power reactors brought into operation anywhere or even for the number of new contracts placed. It has nevertheless been a year of intense activity all the way along the line from the development laboratory to the commercial manager's office and if little of this has seen the light of day yet, presumably 1959 will reveal some results in the shape of new reactor ideas, new contracts and new commercial alignments. Although power being generated from nuclear energy in all countries at this moment is unlikely to total more than about 500 MW, nearly 40 full-scale power stations are in actual construction or definitely planned. Only a very few of these will be completed in 1959 or even in 1960 but from 1961 onwards there should be a great flourishing throughout the world.

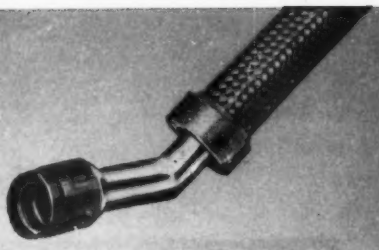
What does 1959 hold for Britain? Firstly Chapelcross will be completed, giving us no less than eight Calder-type reactors on the line each delivering 200 MWt or 46 MWe. The great fast reactor experiment at Dounreay—another first—will become critical and may be worked up to full power during the year. Steady progress at the Berkeley, Bradwell, Hinkley and Hunterston sites is assured and good progress on the Advanced Gas-cooled Reactor experiment at Windscale is expected.

Roundabout mid-summer we may expect to hear which group has obtained the important order for the 500 MW Trawsfynnyd station and later it is possible that the 550 MW Dungeness station also might be decided. At Winfrith, work will probably commence on ENEA's high-temperature gas-cooled reactor joint project.

More speculatively, what could happen? Firstly, it is now generally appreciated that Britain needs badly a 20-50 MW reactor suitable for local power stations and also for marine propulsion. Disclosure at Geneva of the remarkable results obtained in America with EBWR and VBWR has had a powerful impact and a growing body of opinion here is swinging towards the boiling concept—particularly if nuclear superheating can be achieved. It would not come as a great surprise to see some developments announced along these lines. Then there is the fast reactor and it is clear that if Dounreay is to be followed through, 1959 should see the commencement of a much larger semi-commercial fast power breeder. A start on a nuclear ship seems to be indicated if we are not to be left far behind, but which of the warring reactor types ultimately gains the honour of powering it is a question that still has not been resolved.

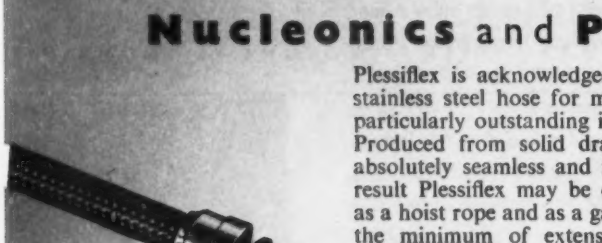
Abroad, the year is likely to be hard one. Armed with their Euratom agreement and flushed with their successes in Italy (ENSI) and Germany (RWE), American companies are now firmly established by commercial agreements in every major European country. It is understood that although the Euratom plan has not been defined yet, it will leave room for gas-cooled reactors. This however does not necessarily mean Britain, for France too has considerable experience in these plants and has the advantage of being right inside the Common Market fence.

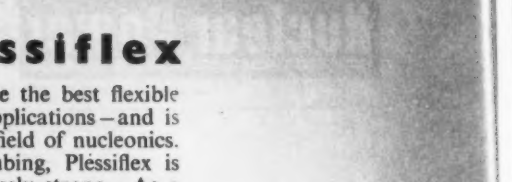
The one thing that could act as a shot in the arm for the British nuclear industry would be a clear and unequivocal fuel policy from the AEA. For many purposes, enrichment is essential and this fuel must be provided somehow if Britain is not to be crowded out of the world's markets.



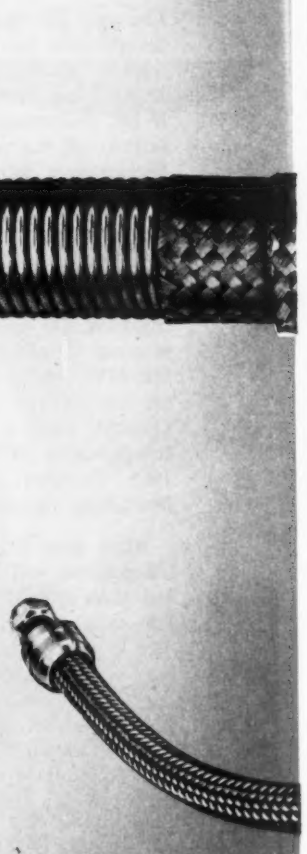
Nucleonics and Plessiflex

Plessiflex is acknowledged to be the best flexible stainless steel hose for most applications—and is particularly outstanding in the field of nucleonics. Produced from solid drawn tubing, Plessiflex is absolutely seamless and immensely strong. As a result Plessiflex may be employed simultaneously as a hoist rope and as a gas or fluid connector with the minimum of extensibility. It is ideal for charging machines, cable conduits, gas ducts, remote pneumatic handling or safety monitoring circuits. High purity aluminium, nickel or zirconium hoses can also be supplied for special applications.





If you have a problem which could be solved by the employment of flexible hose—consult Power Auxiliaries Ltd. Specialists in this field, Power Auxiliaries Ltd., have built up extensive design experience which is readily available to all equipment producers.



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PAL5

Worldview

the month in atomic energy

German prospects fading?

British press reports that a group of South West German electricity undertakings have decided to place an order soon with one of The British consortia for the country's first large-scale nuclear power station have been sharply denied by official sources in Stuttgart. Although it has been widely assumed in the past that this contract would go to Britain rather than America, there is no evidence to support the view that a favourable decision has been reached or even that prospects are as bright as they were. The German group concerned, now represented by the working party Arbeitsgemeinschaft Baden-Württemburg zum Studium der Errichtung eines Kernkraftwerkes, decided over a year ago to install a nuclear power station of about 150 MW capacity and the story from the British end runs like this: following invitations to tender the General Electric Group got in first with a preliminary plan in Dec 57. After a period of tentative exchanges three more British groups tendered around August 58. They were the English Electric and AEI-John Thompson consortia, and the Nuclear Power Plant Company (though the NPPC will not confirm the date). All the schemes are gas-cooled graphite-moderated and since then more or less continuous negotiations about prices and amplification of the bids have been going on between the groups and the Baden-Württemburg concern. Atomic Power Constructions and Mitchell Engineering have not tendered and neither company has any present intention of putting in a bid. The German Babcock and Wilcox is in, and US manufacturers are competing strongly.

The only other possibility for the UK on the German horizon is the Rheinisch-Westfälisches Elektrizitätswerk (RWE) power supply company's plan for a 250 MW station, and the four British consortia are trying for this. General Electric's first offer went in during December 57 followed by English Electric in June 58, and the NPPC. The AEC-John Thompson Nuclear Energy Company will be tendering soon after Christmas.

UK-Euratom pact near

A draft for a treaty between the UK and Euratom has emerged from the prolonged negotiations and is due for approval and signature shortly. On the British side most of the talks were conducted by R. A. Thompson, assistant secretary at the Atomic Energy Office, D. Cape from the Foreign Office and the Atomic Energy Authority's Secretary, D. Peirson. Some of the meetings were chaired by M. I. Michaels, under secretary of the AEO, but there was no specific leader for the British team. A text was submitted to the Euratom Council of Ministers on December 3 but they asked that one article be reconsidered. Talks started again on the offending article and agreement was reached during the third week of December. No details of the treaty have been released officially, but it is reported to be a pretty bloodless affair in comparison with the Euratom-USA pact, containing no provision for a joint research programme, no target for reactors to be built and no financial facilities to prospective buyers.

Private reactors challenged

The Nuclear Installations (Licensing and Insurance) Bill (*Worldview* Dec) ran into three main criticisms during its passage through the Lords. They were: (a) it specifically allows for development and ownership of reactors by private industry (b) it sets a time limit to claims for damage or injury (c) companies with nuclear licences might be taken over by firms who had failed to get a licence. Agreeing with Lord Silkin, who said the opposition believed it would be desirable to restrict licenses to statutory undertakings and Government bodies,

Italy's first Nuclear power station started

THE CELEBRATION

THE CEREMONY

THE WORK

The Italian Prime Minister Signor Fanfani was guest of honour at a dinner given in Rome by the Nuclear Power Plant Company to celebrate the foundation stone laying for the 200 MW nuclear power plant they are building at Latina. Beside him were the British Minister of Power, Lord Mills (left) and NPPC chairman Sir Claude Gibb. During the following ceremony at Latina Enrico Mattei (top right) President of Ente Nazionale Idrocarburi, which is partnering NPPC on the project dropped a cylinder containing a commemorative document into a skip of concrete. Work is already in progress on the site (right).

Lord Wilmot urged that 'the time has certainly not come for the widespread licensing of private enterprise in the use of nuclear energy.' The Minister of Power, Lord Mills, reasserted Government backing for private industry, pointing out that if the UK is to develop export trade in reactors 'private industry must be free to get first hand experience.'

After several objections that the ten year limit on claims was too short the Government amended it to thirty years. Since claims presented after 10 years could not be insured against this will need special arrangements. 'Such claims cannot be settled until Parliament itself has decided how the licensee of the nuclear plant was to be reimbursed,' said Lord Mills. In answer to the criticism that companies with licenses might be taken over by other firms and possibly pass out of British control the Minister of Power said that under the Bill the Government would have full power to reconsider a license. The Bill has now passed through the Lords unimpaired except for the time limit extension: it will go to the Commons early in 1959.

How the money will go

A breakdown of the electricity supply industry's estimated capital requirement of £M2130 for the six years from March 31, 1958, has been given in a brochure 'Power for the Future' by the Electricity Council: Items are:

	£M
GENERATING BOARD:	
Power station construction	1100
Main transmission	270
Nuclear fuel	100
AREA BOARDS:	
Distribution	660
TOTAL	2130

The industry expects to find £M1030 of this from its own resources and is seeking new borrowing powers for the remainder.

Isotope school tops 1000

Over a thousand students have now attended the standard four-week courses at Harwell Isotope School. Set up in April 1951 to give basic training in the safe and effective use of radioisotopes as a tool in research and industry, the school is part of the Isotope Division of AERE. In recent years the scope of the training has widened and the basic four-week courses have been supplemented by specialized courses, generally of shorter duration. These include: isotopes in medicine, radiological protection and autoradiography, short orientation courses for directors and senior executives, courses for science teachers, for water chemists, and for international bodies such as the ILO and WHO.

The 53 basic courses held so far have drawn over 1000 students and the participants in the 24 other courses bring the total to 1725, nearly all of graduate level. They include representatives of 50 countries, 64% being from Great Britain and a further 12% from the Commonwealth. Many branches of science are represented, but chemistry heads the list with 37%, followed by medicine with 18% and physics with 14%. 40% have come from industry, 30% from Government and other research laboratories, including the AEA. Universities supply 22% and hospitals the remaining 8%. A number of technical colleges are holding part-time courses and there are a few full-time courses and research teams in universities. There is however no sign of a reduction in the numbers of students wanting to come to the Isotope School at Harwell: in fact there is a continuing demand for new courses.

JAPAN When completed the Japan Atomic Energy Research Institute of Tokai Mura will house three reactors: JRR-1, an Atomics International 50 kW homogeneous aqueous-type is already in operation in this building. The heavy water high power research reactors JRR-2 (AMF 10 MW enriched uranium) and JRR-3 (Japanese designed 10 MW natural uranium) are due operational in '59 and '60

AEA builds computer team

The number of computation problems arising in reactor development has led the AEA to set up a Computer section in its Industrial Group's Research and Development Branch. A Mercury digital computer was recently put into operation and a large-scale analogue machine (PACE) will be installed next spring. The group is headed by Dr Gordon Black; 'We have built up a team of fifteen mathematicians and programmers who have had experience on the Ferranti Mercury, English Electric's Deuce, and the IBM 704', he told NUCLEAR POWER. 'Extensive use is now being made of the Mercury and the Section has access to an IBM 704. We plan to run the Mercury eventually 24 hours a day'. The Authority is expanding the group by taking on more mathematicians and physicists who will be trained within the section.

IEE plans fusion convention

The Institution of Electrical Engineers has arranged a convention on thermonuclear processes to be held in London on April 29–30, 1959. Details of the programme have not yet been finalized 'in view of the rapidity with which the subject is developing,' say the IEE, but the probable range of topics to be covered is: basic physics of thermonuclear processes; prototype British thermonuclear experiments—ZETA I, SCEPTRE III and the linear pinch; constructional features of ZETA I; design problems in future ZETA-type systems; possibilities of direct conversion from nuclear to electrical energy.

Reviews of related work in the US and the USSR will also be included. Sir John Cockcroft, AEA member for research, will open the programme, which is to

New head for Harwell Metallurgy

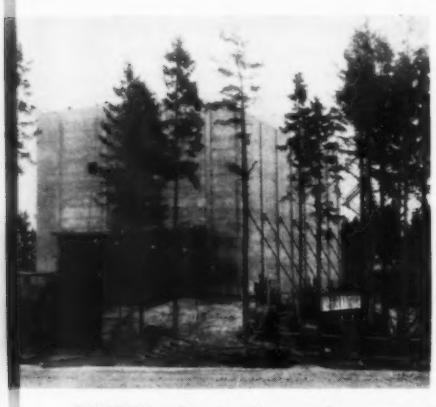
Successor to Dr H. M. Finniston as head of the Harwell metallurgy division is L. Grainger, who moves from the AEA Industrial Group. A first class honours man, he got his degree by part time study while working in steel plants before the war. After serving with the RAF he joined the Admiralty research staff in 1947 and moved to the AEA in 1951

consist of papers and discussions, and the closing contribution will be by Sir George Thomson, Master of Corpus Christi College, Cambridge.

DENMARK

Another setback on DR2

A second mishap on Denmark's second research reactor, DR2, was reported recently by officials at the Risö research centre. Sixteen of the twenty graphite reflector blocks were found to be leaky, and there was a possibility of 'catastrophic' results. The 5 MW enriched uranium light water moderated tank type reactor was supplied to the Danish Atomic Energy Commission by the American Car & Foundry Co. It was originally scheduled for operation early in 1958 but defects were discovered in the tank. This, like the graphite blocks, was built by the US Foster Wheeler Co. Officials said at the time that the setback would cause 'considerable delay' to the atomic energy programme. A new tank was made by a Danish firm and it had been hoped to get the reactor critical by the end of 1958. Cost of repairs following the latest mishap have been estimated at £3000. 'The faulty elements will be repaired in Denmark,' Hans von Bülow, spokesman for the AEC, told NUCLEAR POWER. The Commission is determined to allow no further delay in the startup programme. 'We will bring the reactor up to criticality without the graphite elements,' he said.



SWEDEN Atomic Energy Company of Sweden's research building at Studsvik containing R2, a 30 MW light water moderated and cooled tank-type reactor built by the American Car and Foundry Company, is now complete

GERMANY

100 MW plan gets go ahead

SKW (Studiengesellschaft für Kernkraftwerke GmbH), the joint study group set up by seven North German power companies, have awarded design study contracts for their planned 100 MW nuclear power station to the German associate of Babcock & Wilcox and the Allgemeine Elektrizitäts-Gesellschaft (AEG). The two companies can choose their own type of reactor and Babcock and Wilcox's will be a gas-cooled graphite-moderated design. If a building contract should be awarded on completion of the study, which will take about two years, the company would be able to carry out most of it in Germany. However they might have to go overseas for some of the more complicated parts and in that case would almost certainly order from their British associate. AEG will work out a boiling water scheme—they are linked with International General Electric by technical cooperation agreements and are main contractors for the 15 MW BWR which IGE are building with them for the RWE power supply company—and they are reported to be considering the inclusion of steam superheating.

JAPAN

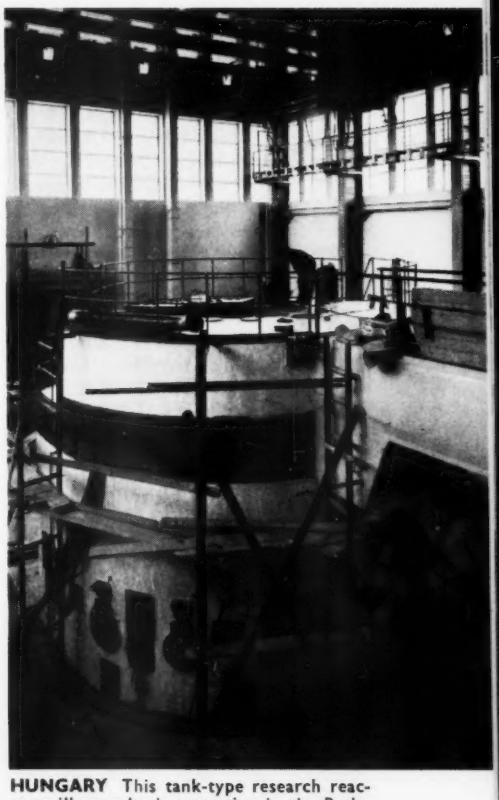
Power group signs with UK firm

An agreement for 'technical cooperation' with the UK General Electric group has been signed by the Fuji Electric Co, leading light of the 14 firms making up the First Atomic Power Industrial Group. It is subject to approval by the Japanese Government. Fuji said in Tokyo that the agreement provided for licensing arrangements for the construction of nuclear power stations in Japan or anywhere else in the Far East, so that the company would be able to undertake work on GEC's behalf. Licensing fees paid by Fuji would be between £140,000 and £180,000 with royalties of 4% to GEC and 3% to the UK Atomic Energy Authority. In London a GEC spokesman stressed that no order for a nuclear power station has yet been placed and the agreement covers technical cooperation as well as licensing arrangements. He said the cooperation already existing would be stepped up to provide Fuji with detailed knowhow on atomic power generation.

LATIN AMERICA

Design for advanced BWR started

The Water Resources Authority's second proposal to the US Atomic Energy Commission for a boiling water nuclear power plant incorporating a nuclear fired superheater has produced some action. The AEC announces the award of a design study contract for a 15 MW plant to the General Nuclear Engineering Corporation of Dunedin, Florida. Cost to the Commission will be $250,000 and the work should be completed in about eighteen months. Approval of the design study does not represent a commitment to build a reactor in Puerto Rico says the Commission. It goes on to point out that although superheated steam has the potential of reducing capital and fuel costs, there is insufficient engineering data at the present time to determine if the additional design complexities introduced by nuclear superheat would prevent realization of the expected gains.



HUNGARY This tank-type research reactor will soon be in operation in the Budapest research centre. It is a Soviet design, employing enriched uranium oxide aluminium alloy fuel elements

UNITED STATES

Fifty utilities back HTGR plan

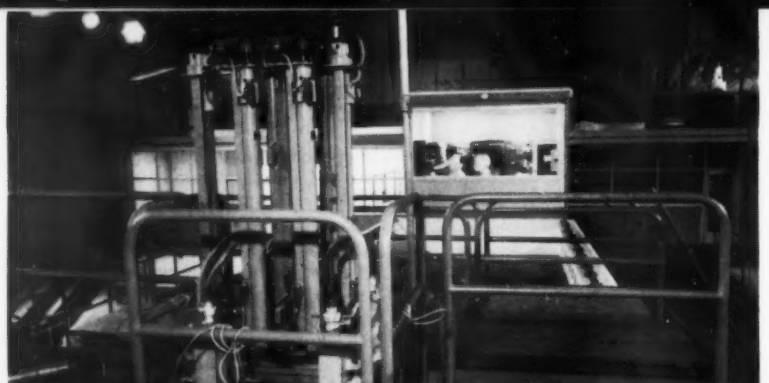
The Philadelphia Electric Co and over forty other supply companies have offered to build a 30 MWe high temperature gas-cooled graphite-moderated plant by the end of 1962. The proposal was submitted in answer to an Atomic Energy Commission enquiry (*Worldbrief* November) and no other proposals were received by the deadline date. The company responsible for the nuclear work would be the General Atomic Division of General Dynamics, which has been concentrating on this type of reactor since the division was formed about two years ago. Their designers are headed by the ex-Harwell scientist Peter Fortescue,

who was largely responsible for the original high temperature gas-cooled concept now incorporated in the British programme. General Atomics propose to bypass the stages traced by the UK Atomic Energy Authority and go for the most advanced type at one jump. Their actual construction experience so far has been limited to research reactors like the TRIGA.

Initially, in order to meet the government's limited time scale, the reactor may be provided with metal-clad fuel elements containing homogeneous carbon compacts of U-235 carbide and thorium carbide. However, beginning with the second core loading compacts containing carbides of U-235 and thorium nested in long large diameter graphite cylinders will be used. The proposal envisages a flow system for the coolant (helium) along similar lines to the British AGR, so that the pressure sustaining materials are in contact with it at the reactor inlet temperature only. With its initial loading of metallic-clad fuel elements, the plant would produce about 30 MW from steam at 850 deg F and 850 psi. Vital statistics using the graphite-canned fuel elements are quoted as :

Electric power (net)	40 MW
Thermal power	115 MW
Helium inlet temp	662 deg F
Helium outlet temp	1382 deg F
Helium flow	440,000 lb/h
Steam pressure at turbine	1450 psig
Steam temp at turbine	1000 deg F
Steam flow	367,000 lb/h
Thermal efficiency (gross)	37%
Fuel element lifetime (at 80% load factor)	3 yrs

The proposal says studies and cost estimates for large size high temperature gas-cooled nuclear power plant, with an output of about 325 MW, have shown it would be competitive with conventional power in many areas of the US. Entire cost of building the prototype, estimated at $M24·5 would be carried by the sponsors, Philadelphia Electric and High Temperature Reactor Development Associates Inc, a newly-organized non-profit group of utility companies. The offer is contingent on AEC help in research and development up to a ceiling of $M14·5. Main con-



Spain's first reactor opened

The open pool-type International General Electric 3 MW research reactor above was inaugurated recently at the Moncloa facility of the Spanish Nuclear Energy Board (Junta de Energía Nuclear). The control console (left) located in an adjacent room, is just visible in the top picture. The inauguration formed part of the ceremonies officially opening Spain's nuclear research centre and took place about a month after the reactor went critical

INTERNATIONAL

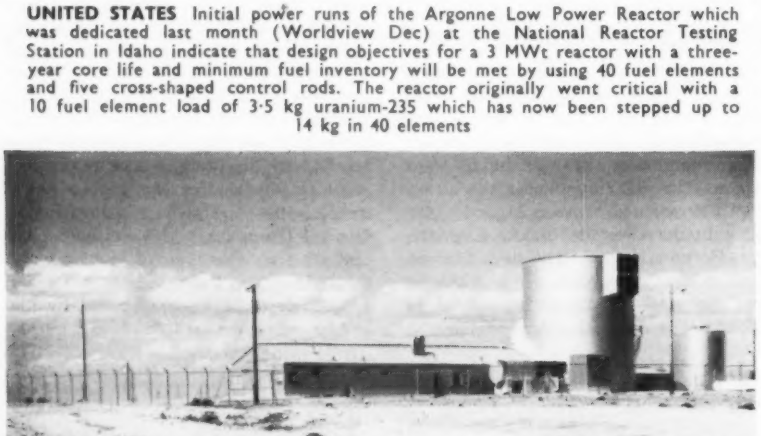
First uranium auction opens

A surprise offer by Canada dominated the first public international 'auction' for natural uranium. Replying to a call for tenders by the International Atomic Energy Agency, Canada offered the required amount—three tons—as a gift. The US sent in a bid by the Davison Chemical Co of Baltimore which quoted $54·34 a kg and the Société Général des Minérais, Brussels, tendered at $34. These were the only bids received by the closing date, Dec 12. Countries which in the past have offered the Agency an option on fissionable materials are Belgium, Canada, Czechoslovakia, India, Norway, Portugal, South Africa, Russia, the United States and the United Kingdom. They were all invited to tender. The UK, as a non-producer, did not make a bid, but the Atomic Energy office points out that the past British offer of enriched uranium to the tune of 20 kg of contained 235 is still open and under spasmodic discussion.

In its offer the Canadian Government stipulated that the IAEA was expected to sell the uranium at something near the world current price. The value of the offer is about $100,000 and the Government stated that it was made 'to expedite the Agency's activities.' Director General Sterling Cole responded swiftly by cabling thanks for the 'unexpected, unprecedented and unselfish offer,' which had been received with 'enthusiasm and gratitude' and provided a 'constructive example' for future support of the Agency by other Governments. Apart from making a start on the Agency's plans to act as a clearing house the tenders were expected to help establish a world price for natural uranium, which would probably be lower than the $40 a kg charged by the US in bilateral agreements. The invitation followed a request by Japan—the first submitted to the IAEA—for assistance in obtaining 3 tons; this is needed for the 10 MWt heavy water research reactor designed and constructed by Japanese scientists. Initial loading when the reactor goes critical about April 1960 is estimated at six tons but Japan intends to find the remaining three from its own resources.

After the Board of Governors has approved the project and chosen the supplier it will be necessary to conclude an agreement between the Agency and the supplier and another agreement between

UNITED STATES Initial power runs of the Argonne Low Power Reactor which was dedicated last month (Worldview Dec) at the National Reactor Testing Station in Idaho indicate that design objectives for a 3 MWt reactor with a three-year core life and minimum fuel inventory will be met by using 40 fuel elements and five cross-shaped control rods. The reactor originally went critical with a 10 fuel element load of 3·5 kg uranium-235 which has now been stepped up to 14 kg in 40 elements



the Agency and the Government of Japan. This is expected to contain clauses about the terms and conditions of sale and the application of Agency peaceful-use safeguards.

IAEA leader attacks US

Bilateral and multi-lateral agreements covering the supply of nuclear fuel are a major factor in the nonfulfilment of the International Atomic Energy Agency's hopes to function as a world bank for fissionable materials, says Director General Sterling Cole in an important article in this issue (p 86). Furthermore, 'A proliferation of bilaterals and regional agreements and projects,' he points out 'can hardly serve the common objective of establishing internationally valid rules and standards.' In this article the Director General steps up the momentum of his fight to get the Agency recognized once and for all as the supreme international body concerned with the applications of atomic energy. His criticisms of the policy followed by national governments has been mounting for some months. Expressing his private views in a speech before the fifth annual conference of the Atomic Industrial Forum in Washington recently he said that the Agency could not achieve its objectives, or even continue to exist, unless there was a change in policy by the US and other nuclear powers. Some three-quarters of the nations of the world were now accommodated by bilateral agreements—about 40 by the US, 12 to 18 by Russia and 10 to 12 by Britain—thus bypassing the international agency. 'If the Agency is allowed to collapse,' he emphasized 'the world will have lost an opportunity to make sure that the fissionable materials produced by the atomic industry will be used for peace and not for war.'

Euratom supply rules fixed

The Statute regulating the operations of Euratom's projected Nuclear Supply Agency has now been published. All ores and fissionable materials produced in the six countries will come under the Agency's right of option, and it will have the exclusive right of concluding contracts on supplies coming from inside or outside the Community. Except in the case of a shortage its role is foreseen as purely that of an intermediary between supplier and consumer. It will make no profit but must cover operating costs. Capital is being provided by five of the six countries: Germany, France and Italy are to contribute 28% each, Belgium and Holland 8%. To keep the two sides—supplier and consumer—of the nuclear industries happy a committee is to be set up with the right of prior consultation on major decisions.

WORLDBRIEFS

● **Belgium** Imperial Chemical Industries have received their first order from a nuclear organization outside the UK—£100,000 worth of aluminium piping for the experimental Belgian reactor BR-II. Contract was placed with two subsidiaries, ICI (Belgium) and Marston Excelsior.

● **United Kingdom** Elliott Automation Ltd have formed a new company, Elliott Nucleonics Ltd, to take over and expand work previously handled by the Group's nuclear division. The CEGB's simulator (this issue p 130) will be built by the new company.

● **United Kingdom** Russian experience in spectroscopic studies of plasma was reported to Harwell on Dec 5 in a lecture by Prof S. L. Mandelshton of the USSR Academy of Sciences Physical Institute.

● **British Guiana** The UK firm Mitchell Engineering is putting a plan for a 20MW boiling water reactor to the government. Mitchell's nuclear manager Gordon Jackson recently visited the colony to talk about the possibility of establishing a nuclear power plant on a site about 150 miles up-river from Georgetown. The area has considerable mining potential.

● **International** The IAEA's 'Manual of the safe handling of Radioisotopes' was published on Dec 5. Prepared by a panel of thirteen experts from ten countries it is the Agency's first technical publication and covers organizational, medical and technical aspects of safety practices.

● **Russia** No confirmation, official or unofficial, is available in Moscow on a report in the American magazine 'Aviation Week' that an atomic powered plane has been built and flown near Moscow. American scientists are sceptical but believe that Russia is ahead in this field.

UNITED STATES Before its shipment to Greece's new 'Democritas' Nuclear Centre near Athens recently this Nuclear-Chicago $127,000 subcritical training reactor was inspected by Queen Frederika and her daughter. Describing the reactor is Dr O. Neville, one of the corporation's technical directors

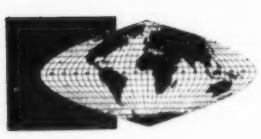
● **United Kingdom** All the reactors at Calder Hall are now working. The second reactor of Calder B station went critical on Dec 8. So far just over 750 million kWh have been fed to the National Grid by Calder A. Delivery of power by B1—held up by the turbine accident last June—is due on or about January 5.

● **Russia** Tests of the nuclear plant for the ice-breaker *Lenin* have been started. All three reactors are assembled.

● **Italy** The State Railways—Ferrovie dello Stato—are making enquiries among British and American firms with a view to building a 10MW training reactor near Rome. About a quarter of the 2000 million kWh consumed each year by the railways is provided by power stations owned by FS which is considering co-operating with industry on the construction of a nuclear power station.

● **Italy** The Government have strongly opposed any tariff discrimination on the importation of reactors from the US as against Euratom countries, said CNRN Secretary General Prof Ippolito recently.

● **United States** The sale of two 10MeV tandem particle accelerators to Switzerland and Australia has been announced by High Voltage Engineering Corporation. They are both to be delivered in 1960. One will go to the Swiss Federal Institute of Technology at Zürich, the other to the Australian National University at Canberra.



INTERNATIONAL COOPERATION IN ATOMIC ENERGY

The year 1958 has seen the emergence as fully operational units of three communities of nations dedicated to the development of nuclear energy as a new force for economic progress. The precise roles of these organizations are sometimes misinterpreted and misunderstood so we asked their directors to start this special issue with analyses of their aims and programmes

The International Atomic Energy Agency

by **W. STERLING COLE** *Director-General*

A FEW WEEKS AGO I presented the second report on the activities of the International Atomic Energy Agency to the General Assembly of the United Nations. This debate in the General Assembly took place only one year after the Agency had been formally established and almost five years after the President of the United States had made his proposal for the establishment of an international body to 'serve the peaceful pursuits of mankind' in the atomic energy field.

What did the founders—first consisting of representatives of eight and later of twelve countries preparing a draft statute, then of an 81 Member Statute Conference and finally of a Preparatory Commission consisting of 18 countries—have in mind? Why was there such a unanimous desire and will to establish 'yet another' international organization under the aegis of the United Nations?

To answer these questions we must try to recall the climate of that period. All efforts to reach an agreement on some form of control over the military uses of atomic energy had failed. At the same time rapid progress was made by the 'atomic powers' in the use of nuclear power for civilian purposes. The US Act of 1954, for instance, with which I was closely associated, gave industry access to data and materials and opportunity to invest in the development of atomic energy. The Act also foresaw and facilitated international cooperation in the atomic energy field. It was the period of the first Geneva Conference, the period when the slogan 'Atoms for Peace' was still something of a novelty.

The proposal by President Eisenhower really meant a new approach. Even if the major powers could not agree on military controls or what might be called the negative aspect of atomic energy, this should not allow efforts to work internationally for the accelerated use of the constructive power inherent in nuclear energy to be thwarted. The President specifically urged the atomic powers to 'make joint contributions from their stockpiles of normal uranium and fissionable materials to an international atomic energy agency.'

One of the major tasks foreseen from the very beginning for the Agency was thus as a bank for fissionable materials. At the time of the first Geneva Conference there was wide recognition of the enormous opportunities of supplying the power-short areas of the world with a new source of energy, and the services of the Agency were expected to hasten this new industrial revolution. These hopes have not materialized nor has the supply function proved to be the main task of the IAEA so far. Considerable quantities of fissionable materials have been made available to the Agency but requests for such materials have up till now been limited to one from Japan, made known recently, for the small amount of three tons of natural uranium of reactor grade.

Thwarted plans

There are certain obvious reasons for this non-fulfilment of the original plan. To start with, there has been a revision in the estimates of the feasibility of introducing nuclear power in the under-developed countries. It will take considerably longer than was thought in most quarters in 1955 and it will depend on the successful completion of many preparatory phases and the development of small or medium-sized reactor types suitable and economic for such areas. In the technically advanced countries which do not belong to the 'atomic powers'

there is however a demand for nuclear fuels and for the financing of atomic energy projects. These demands so far are being met mainly through bilateral or multilateral agreements, which constitutes another major factor in the nonfulfilment of the Agency's supply function. The supplies offered through the intermediary of the Agency must be at least as attractive in terms of price and delivery as those offered outside its aegis.

World broker ?

The acceptance of materials and services through the IAEA carries with it certain obligations as to health and safety standards and safeguards against diversion to military uses. The health and safety aspects have not met with any opposition or special difficulties and codes are now being worked out in a wide variety of fields. The first code or manual deals with the safe handling of radioisotopes and was issued as the Agency's first technical publication on December 5. Work on a similar manual for the disposal of radioactive wastes into the sea is under way and an international panel under the chairmanship of Mr Harry Brynielsson of Sweden will meet shortly to consider this question. Transport of radioactive materials will also be tackled early next year. These regulations or recommendations will be applied to all of the Agency's own activities in terms of the Statute but it is also expected that they will serve as guides to national regulations, thus achieving a much-needed international harmonization of practices and codes.

The problem of safeguards is not quite so straightforward. The clauses in the Statute requiring such safeguards for any Agency project were drafted when the Agency was thought to become the main 'broker' of fissionable materials moving in international trade. In some quarters the utility of 'safeguarding,' for instance, the three tons of natural uranium going to Japan through the Agency has been questioned. This is perhaps natural, as any safeguard in respect to this limited amount has very little significance *per se*. The Japanese project therefore is of key importance because it may be the beginning of something that could grow as a chain reaction. It is of the utmost importance that the safeguards, procedures and standards now being worked out by the Agency are neither so strict that from a cost point of view alone they would be impracticable, or so lax that they really would not be effective.

Japan and the United States have also announced their intention to place their bilateral agreement under IAEA safeguards, which according to the Statute is possible for any signatories of a bilateral or multilateral agreement. Provisions have also been made in a number of other bilaterals for an eventual handing over to the Agency of the safeguards responsibility. I personally attach great importance to the potential work of the Agency in this field.

An international certification under generally accepted procedures would do much to create an atmosphere of confidence without which no real progress in the peaceful applications of atomic energy can be expected on a world-wide scale. Our system of safeguards, now being worked out, would mainly be based on accountability of materials; what has been generally called 'inspection'—that is the necessary action to ascertain that the accepted procedures have been complied with—might be better named 'external audit.' If, through the Agency, an international system of accounting accompanied by a system of auditing could be generally accepted, a major step would have been taken towards accelerating the use of atomic energy for peaceful ends.

First things first

Some of the main functions originally foreseen for the Agency have of necessity been left backstage during our first year of operation and planning. This does not in any way mean an abandonment of these tasks, but merely a policy of first things first and an acceptance of today's climate, which has changed somewhat from what it was in 1954–55. What most countries in the under-developed regions need at present is trained personnel, advice on their overall atomic energy development plans, assistance in applying isotopes to industrial and medical uses and research and studies on reactor designs and economics. In all these fields the Agency is now busy. Requests from some twenty countries are being studied and in some cases we have sent small teams of experts to make preliminary studies of the possibilities. We will send the first general atomic energy survey team to South-east Asia in January. We have placed a substantial number of young scientists and technicians as IAEA fellows in universities and research institutes in member countries. The Agency has begun to serve as a clearing house for scientific information and we have already placed research contracts with institutions in member countries, particularly in the health and safety field. I am well aware of the fact that some impatience has been voiced with the speed of our achievements. I share that impatience—but at the same time I cannot, in looking back at this first year of existence, help sharing the opinion expressed by Sir Edwin Plowden at our General Conference that this is not a valid criticism.

International collaboration on a scale as large as that of the Agency—there are at present 69 member countries representing all the major regions of the world—cannot by its very nature make very rapid or spectacular progress. The machinery alone for such collaboration is complicated and demands time to move from one phase of the process to another. This is true of all international work, but perhaps particularly in that of atomic energy, where science and politics and diplomacy are joined.

In the case of the International Atomic Energy Agency the machinery established by the Statute differs somewhat from what is normal in other organizations within the United Nations family. The Board of Governors is responsible for 'carrying out the functions of the Agency' and thus has the responsibility of a managing directorate but is constituted as a parliament. It has duties which in most other agencies are entrusted to the Director General. Our first year therefore has been a test year in this respect also, as the constitutional provisions had to be translated into practical procedures and working arrangements. This has been successfully accomplished and is in itself, I think, a not unimportant part of our achievements during the initial year.

The Agency also fits into a larger framework—the framework of the United Nations and the specialized agencies and also of other international organizations, regional or world-wide, that are interested in the peaceful uses of atomic energy.

UN's atomic arm

Our origin and Statute make it clear that the IAEA has a specially close relationship to the United Nations, both historically and functionally. Almost every speaker during our General Conference stressed that this relationship should if possible be made even more intimate and we are doing everything we can to respond to this obvious need. In this connexion I attach great importance to the decision by our Board of Governors, approved by the General Conference, that IAEA should join the expanded programme of technical assistance of the United Nations. The Scientific Advisory Committee to the Board of Governors and the Director General, which held its first session in the middle of November at UN headquar-

ters in New York, is composed of the same seven wise men from among the world's outstanding scientists who advise the Secretary General, Mr Hammarskjöld, on atomic energy matters. They are: Prof H. J. Bhabha (India), Sir John Cockcroft (UK), Prof V. S. Emelyanov (USSR), Prof B. Goldschmidt (France), Prof B. Gross (Brazil), Prof W. B. Lewis (Canada) and Prof I. I. Rabi (USA).

I very much hope that the identical composition of the two committees will further the development of a 'personal union' between the UN and IAEA, which is of increasing importance as the Agency tends toward becoming what has been termed 'the atomic arm' of the United Nations.

The IAEA now also has formal relationship agreements with all the specialized agencies interested in atomic energy: ILO, FAO, UNESCO, WHO and WMO. These agreements have been concluded to make sure that the best possible coordination be achieved.

Problems and passions

The Agency's relations with governmental international agencies outside the UN family are slightly more complicated and have not yet been formalized. The Board of Governors decided to invite a number of these organizations as observers to the second session of the General Conference. Invited were for instance Euratom, CERN, the Joint Institute for Nuclear Research at Dubna and the European Nuclear Energy Agency (OEEC). The absence of any formal agreements with these organizations does not lessen the Agency's interest in their activities, which in most cases are supplementary to those of the Agency. All constructive efforts to accelerate the peaceful uses of atomic energy are, of course, welcome reinforcements in pursuit of the statutory objectives of IAEA. On the other hand it is clearly one of the duties of our Agency to try to establish certain internationally valid rules and standards in many fields touching upon health, safety, and safeguards. A proliferation of bilaterals and regional agreements and projects, without a uniformly applied and internationally accepted set of rules for health and safety and materials safeguards, can hardly serve this common objective. I very much hope in the coming year to have detailed discussions with my colleagues in these organizations and work towards a *modus vivendi* that will benefit our common aim. It was made clear however during our last General Conference that such collaboration raises political problems and passions.

Euratom :

The European Atomic Energy Community

by **LOUIS ARMAND** *Commission President*

IT IS NOW just a year since the treaty establishing the European Atomic Energy Community, came into force. Euratom's first twelve months of activity have seen a number of major achievements, including the conclusion of an agreement for cooperation with the United States, and the negotiation and drafting of an agreement with Great Britain. January 1, 1959, Euratom's first anniversary, sees the establishment of a Common Market for nuclear reactors and a large number of nuclear materials, which will henceforth be able to pass freely throughout the six Community countries without national restriction or hindrance. This, then, is perhaps a good moment to take stock of the reasons why Euratom was established, what it is, what it has done, what it plans to do, and how it fits into the world picture in the realm of atomic power.

Dual revolution

First of all, why was Euratom set up? The answer is implied in the very word 'Euratom' itself, which seems to have passed into common currency since its first use some three or four years ago. Various people, it is true, pronounce it in different ways. My own compatriots in France call it 'Er-ah-tome,' our German partners call it 'Oi-ra-tome,' and our British and American friends, I am told, call it 'You're-at-'em.' But however one pronounces it, it is a name which couples two of the major revolutions which have come in the lifetime of all of us. The first is the revolution in the face of Europe—the movement for European economic integration. The second is that which has been brought about by the unlocking of the secrets of the atomic nucleus. Euratom, as its name implies, marks the point where these two processes converge.

Perhaps the first significant date in the history of unity in Europe is 1948, when the Organization for European Economic Cooperation (OEEC) was set up in response to Marshall Aid. The achievements of the OEEC are there for all to see. In ten years' hard if unspectacular work, it has helped its 17 member nations to get on their feet again, and to take powerful strides forward. On the political side, 15 of those same have found a forum in the Council of Europe, set up in 1949. No one, I am sure, can fail to realize the very great contribution which both these broader European organizations have made to cooperation in Europe. But cooperation, for many Europeans, was not enough: and this was one of the reasons why in 1950 Robert Schuman made the famous Declaration that led six nations to surrender a part of their sovereignty to the institutions of the European Coal and Steel Community, set up in 1952.

Plans for unity

It would be pointless to explore the well-trodden paths of legalistic controversy over the significance of the terms 'cooperation' and 'integration,' and over the question of whether or not the institutions of the ECSC are supra-national or not. Yet, while it is true that the signature of any treaty in some degree limits the sovereignty of the states involved, it is equally true that no treaty obligations hitherto undertaken had involved so large a limitation of sovereignty and so definite a transfer of power. The ECSC, although limited to the six states which had found themselves able to join it, has proved an undoubted success. It in turn led to a further proposal—for a European Defence Community (EDC) and a European Political Community, both of which unfortunately collapsed when the French National Assembly failed to ratify the EDC Treaty. But despite this temporary setback, the same six nations went on with further plans for unity at the Messina Conference in 1955, leading to the two Treaties of Rome signed on March 25, 1957, one establishing the European Economic Community, the EEC or Common Market, the other establishing Euratom.

Euratom, therefore, forms a part of a six-nation drive towards integration within the general framework of European cooperation. It shares the institutional structure of the ECSC and the EEC, with a joint Court of Justice and a joint European Parlia-

ment to supervise the separate but related executive bodies of each Community.

Long before the Euratom treaty was concluded, previous studies made by the OEEC for the 17 nations, as well as by the ECSC for the six, had made it clear that Europe's indigenous supplies of energy were less and less able to meet her mounting needs. It was in order to have a detailed view of this situation, and of how it might be remedied by atomic power, that even before the conclusion of the Euratom Treaty the six governments appointed the three-man committee of which I had the honour to be a member—the so-called 'Three Wise Men.'

The conclusions of this committee underlined the urgency of the energy problem for our six countries, whose energy imports—chiefly in coal and oil—cost them some 2 thousand million dollars in 1957 and would probably cost some 4 thousand million in 1967 and some 6 thousand million in 1975 (at 1957 price levels). Only a substantial nuclear power programme, the committee concluded, could hope to keep energy imports within reasonable proportions. The target proposed was 15 million electric kilowatts of installed nuclear capacity by the end of 1967—an ambitious target even in comparison with those planned in Great Britain, the United States, and the USSR.

Power target

This proposed Euratom target has been much discussed— and sometimes criticized—in recent years. It may be well to emphasize that the figure of 15 million kilowatts is based on an extrapolation of future energy needs and represents the volume of nuclear power which would be necessary to stabilize future energy imports at their expected 1963 level—that is, at about 165 million tons (hard coal equivalent) or some 3300 million dollars (at 1957 price levels). The target is not, and was not intended to be, a prediction of what existing private and national projects would achieve, or a 'plan' to be imposed on the Community. Indeed, even with the aid of such pooling of resources and with the stimulus that Euratom may hope to bring about, it seems unlikely that the 15 million kilowatt target will be reached within the time laid down.

Recent surveys completed by the Euratom Commission suggest that on the basis of existing industrial projects, only some 4 to 5 million kilowatts will be installed by 1965—which in a sense makes the remaining two years until 1967, the date for the larger target, of crucial importance. It is clear, therefore, that Euratom has an essential role to play, both in helping to coordinate national programmes, and laying the necessary basis of research and exchange of information, as well as in supplying a stimulus to further effort. Here, therefore, political and economic motives fuse into one.

Sevenfold task

The specific tasks of Euratom are perhaps best described in the Rome Treaty. Briefly, they fall into seven main categories: research, training, and dissemination of information; health and safety protection; stimulus of investments and the construction of basic facilities; supplies; security control; the nuclear Common Market; and external relations.

In the field of **research and training,** the Commission has already drafted its first research programme, in cooperation with existing research centres and projects and with work being done in non-member countries. The main lines of its activities will include the setting up of the Community's joint research centre, the study and construction of experimental, test, and prototype reactors, work in connexion with power reactors, the study of fusion, radioisotopes, radiation effects, and other related subjects, the establishment of a standards bureau, and the setting up of a training centre at university level.

The Commission has already drafted, with the aid of its Scientific Technical Committee, standards for **health protection** which are based on the latest and most comprehensive studies in this field. They represent binding obligations, on which the Community's member states must themselves legislate; in the opinion of our experts, they are more than adequate to assure the health and safety not only of the workers engaged in the nuclear industries but also of the civil population as a whole.

In the field of **investments,** one of the Commission's first tasks was to survey the degree of progress already achieved in the Euratom countries at the time when the Community came into being. This survey was completed and published by June 30, 1958. It revealed that the total capacity of the eight power reactors then built, planned or under construction, would be in the region of 660,000 electric kilowatts. Of these reactors (five in France, two in Italy, and one in Belgium), the only one then in operation was G-1 at Marcoule. All important nuclear investments now have to be communicated to the Commission, which thus can keep a close watch on the future plans of private and public industry, and which will do its best to stimulate, facilitate, and guide future investments, without in any way following a policy of *dirigisme*. In certain cases, the treaty permits Euratom to develop joint enterprises of particular importance or interest to the whole Community, but as yet no decisions have been taken in this field.

On the subject of **supplies,** the Euratom treaty was perhaps more pessimistic than it need have been, for at the time it was drafted no one was certain what the future state of the supply situation might be. At present, however, there seems no apparent risk of a shortage of fissionable material, and the supply agency provided for by the treaty to ensure fair and equal access to ores and fuel will in all probability limit its role for the moment to that of a broker. The Commission has already drafted a statute for the Agency, which will shortly come into operation.

Pooling resources

Closely connected with the question of supplies is that of the use to which fissionable material is put, and one of Euratom's most important tasks is to establish a system of **supervision** (or what in my own language is more conveniently called *contrôle*) to ensure that it knows exactly how much fissionable material exists within the Community's frontiers, where it is, and how it is being used, in order to avoid its getting into unauthorized hands for unauthorized purposes. Member states, nevertheless, retain the right to use fissionable material for specific defence purposes, and Euratom's inspection system stops, so to speak, at the gates of military installations—just at the point, that is to say, where any eventual international control of atomic weapons—by the IAEA, for instance—will begin.

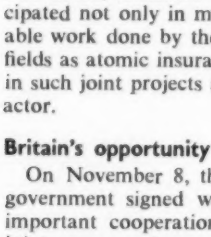
I have already mentioned the **Nuclear Common Market** which will open on January 1, 1959. Although limited by comparison with the Common Market for all goods and services which is gradually to be established by the European Economic Community, this too is an essential element in the pooling of our six nations' atomic resources which is one of the essential aims of Euratom.

Finally, in the field of **external relations,** the Community has been extremely active during its first year of existence, having established friendly contact not only with the IAEA in Vienna, and with CERN in Geneva, but also, on many levels, with the European Nuclear Energy Agency which groups the countries of OEEC in a flexible system of international cooperation. All Euratom's member

states are themselves members of the ENEA and subscribe well over 50% of the capital of its Eurochemic Company. Since the Euratom Treaty came into force, Euratom has itself participated not only in much of the valuable work done by the ENEA in such fields as atomic insurance etc, but also in such joint projects as the Halden reactor.

Britain's opportunity

On November 8, the United States government signed with Euratom an important cooperation agreement for joint power and research programmes which are now getting under way. This was followed in December by the approval of the agreement between Euratom and the United Kingdom which, although less far-reaching than the joint plans envisaged with United States, nevertheless opens the whole Euratom Market to the sale of British reactors. In fact, it is Euratom's wish that the Community should have the chance to move ahead not only in the field of enriched uranium reactors favoured by the Americans, but also in the field of natural uranium reactors, already brought to so high a pitch of development in Great Britain. For Europe's atomic future can only be assured by research and investment on the widest possible front, and in close cooperation between the nuclear industries of the whole Western world. The field is open: it is now the task of British industry to ensure that Britain makes the fullest use of the opportunities afforded it by the nascent nuclear industry in the six countries which it is Euratom's duty to foster.



The European Nuclear Energy Agency

by **PIERRE HUET** *Director*

ON FEBRUARY 1, 1958 the Council of the Organisation for European Economic Cooperation established the European Nuclear Energy Agency. This action marked a most significant stage in the efforts of the OEEC since 1953 to promote among its 17 member countries* increasing cooperation in planning to meet future European demands for power.

The first step in this direction had been taken at the beginning of 1954 when a study was made on behalf of the Organisation by Louis Armand (then chairman of the French National Railways, and subsequently to become chairman of Euratom) of the overall problems of future energy supplies and how these might be solved. M. Armand's report laid special stress on the ultimate importance of nuclear power, a view which was confirmed by a group of experts under the chairmanship of Sir Harold Hartley which was set up shortly afterwards by the OEEC Council. Their report estimated that, at the current rates of consumption, the deficit in conventional fuel and power supplies of member countries would by 1975 be equivalent to some 400 million tons of coal per year, or more than one-third of their total requirements.

In face of this prediction it was evidently of vital importance to investigate as soon as possible whether cooperative action between countries could help to speed up the development of nuclear power supplies, and in June 1955 the OEEC Council set up a working party, consisting of three independent experts under the chairmanship of Professor Nicolaidis of Greece, for this purpose.

The report of this working party can be said to have provided the basis from which all subsequent OEEC action in the nuclear field developed, from the initial establishment of a special committee for nuclear energy, charged with implementing the working party's proposals, to the creation, on February 1, 1958, of the European Nuclear Energy Agency.

Promoting cooperation

The purpose of ENEA can be broadly defined as the promotion of cooperation between member countries in developing nuclear energy for peaceful purposes. This is an exact extension of the purposes and principles of the OEEC in a great many other fields, and the Agency does in fact work in constant and close association with all the other branches and institutions of its parent body, particularly those concerned with conventional energy sources and with productivity.

The executive body of the Agency is the steering committee, which comprises representatives of the 17 member countries of the OEEC and the associated countries, Canada, USA and Spain. A representative of the Euratom Commission also attends meetings of the committee.

The steering committee is competent to deal with all questions related to the objectives of the Agency. It comes under the authority of the Council of the OEEC, to which it reports regularly and which is solely responsible for decisions imposing obligations on governments. In the absence of special delegation therefore it has no power of its own, although it can if it wishes make recommendations to the countries taking part in its work.

This work is mainly carried out through technical commissions and working parties which the steering committee sets up as it deems necessary. One of the most important is a committee of top-level experts in nuclear science and engineering from member and associated countries and from Euratom, set up last February under the presidency of Professor Perrin of France and Sir John Cockcroft of Great Britain, which is examining possible methods of European collaboration in the experimental investigation of various types of reactor for power production. This is a field which is specially suited for collaboration for there are so many possibilities that no one country alone could afford either the money or the technical manpower for a comprehensive practical study.

Catalytic action

The form of action which this or similar types of joint project may ultimately lead to can vary considerably. For example, the European Company for the Chemical Processing of Irradiated Fuels, Eurochemic, is a mixed-investment company (government and private capital) controlled by a board of directors appointed by the various countries taking part, whereas the direction of the Halden boiling heavy water reactor project in Norway is vested in the Norwegian Institute of Atomic Energy, assisted by experts from all countries taking part and with the collaboration of the United States.

*Austria, Belgium, Denmark, France, Federal Germany, Greece, Iceland, Ireland, Italy, Luxemburg, Netherlands, Norway, Portugal, Sweden, Switzerland, Turkey, and United Kingdom. Canada, U.S. and Spain are associated with the work.

Thus ENEA does not retain direct control of its projects once they are launched and under way. It decentralizes as soon as possible, for only thus can it continue to seek out and inaugurate new undertakings without an enormous increase in size. ENEA representatives nonetheless remain in close touch with all the work, and further help from the Agency is always available if required.

Thus the action of the Agency is that of a catalyst rather than of a major contributor of men, money or materials to the ultimate development of international projects. Without such catalytic action, however, the launching of the projects would be exceptionally difficult and probably impossible.

Joint projects

Eurochemic This company, the first international undertaking with an industrial objective, was formed on December 20, 1957, by the signature of an international convention by 12 OEEC member countries. It is a mixed-investment company with a capital of 20 million EPU units (approx £M7) in which governments, public or semi-public institutions as well as private groups or undertakings can participate in financing and running the business.

The first objective is to construct a plant for processing the various fuels from research or test reactors. This plant, which is expected to start operating in 1961, will have a capacity of 100 tons of fuel per year and will also serve as a pilot plant for the building of the much larger installations which will be necessary in 1964/65 to treat the uranium used in Europe's nuclear power stations. The plant, together with laboratories and other facilities, will be built close to the Belgian nuclear study centre at Mol. Preparatory work for the layout of the site and construction of the plant is being done in a study and research office established at Mol by ENEA.

Halden reactor This is the first result of a study project to investigate the possibilities of various types of reactor which might be used for power production. The reactor has been built by the Norwegian Atomic Energy Institute and is expected to become divergent early next year. Under an Agreement signed on June 11, 1958, it is to be operated in the joint interests of 12 OEEC member countries, six of which will be participating through their membership of Euratom.

The research programme to be followed will be directed by an international technical committee and will be carried out by the Norwegian Institute, which will set up for the purpose a team of experts from the signatory countries. The United States will also collaborate in this work.

HTGC More recently, as a result of United Kingdom initiative, another very important project has been proposed. This is for the construction of a high-temperature gas-cooled reactor and for carrying out a five-year joint research programme to investigate the possibilities of this very advanced and theoretically very promising reactor type. The project is at present the subject of discussions between 13 OEEC countries and the Euratom Commission. Facilities for building and operating the reactor have been offered by the UKAEA at Winfrith Heath and the five-year joint research programme proposed is estimated to cost some £M13. Final agreement between the countries concerned to start this work is expected very shortly.

Heavy water At the end of December, 1957, the steering committee for nuclear energy decided to study the possibility of producing heavy water in Iceland using the geothermic steam available there. A group of experts assessed the industrial and financial implications of this project and concluded that for an annual capacity of 200 tons the capital outlay would be in the region of $M40 and, provided a fairly long period was allowed for amortization, the cost of production would be about the current selling price in the United States.

Organization problems

The work of ENEA falls into two classes. Besides projects mainly concerned with the technical development of nuclear energy in Europe such as those just described there are also many organizational and legal problems raised by this development. These concern such matters as health and safety standards, third party liability and insurance, the training of technical and scientific personnel and the development of a system of inspection and control which, both technically and legally, can be relied upon to prevent the use of the joint facilities for military purposes.

Health and safety In 1957 a programme was adopted to develop, for all member countries, common health and safety standards to protect the public and workers from nuclear hazards.

Insurance Because of the nature of nuclear risks, the third party liability of the operators of nuclear installations must be subject to special legal provisions. A draft convention has been prepared which would subject such operators to absolute liability for damage arising out of a nuclear accident. This liability would exclude any liability on the part of manufacturers, suppliers or contractors; on the other hand it would be limited in amount and in time and the operator would be bound to provide financial security for his liability.

Training In examining the existing European facilities for technical and scientific training, ENEA has been primarily concerned to help member countries cooperate in making the best possible use of these facilities. One way of doing this is the regular publication of details of all courses available in nuclear science in these countries.

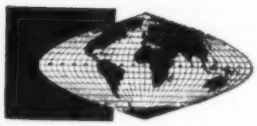
Security control On December 20, 1957, all the member countries of the OEEC signed a convention on the establishment of a security control to prevent the use of joint nuclear facilities for military purposes.

The coming into force of this convention is subject to its ratification by the signatories and this has not yet taken place. When it has, ENEA will be largely responsible for ensuring its operation, particularly for setting up and directing the work of a central control bureau.

Parallel development

The reasons for establishing ENEA, and the purposes for which it was established, date from at least three years ago, during which time a number of parallel developments in the European nuclear picture have taken place. Some of these, notably the creation of Euratom and of the worldwide International Atomic Energy Agency of the United Nations, have a close bearing on the work of ENEA which, by its statute, is expressly bound to take account of the work of other international organizations in the field and to cooperate with them in all possible ways.

As has been shown, there is close collaboration between ENEA and the Euratom Commission. This covers participation of Euratom representatives in the work of the Agency's steering committee and working groups, as well as in many of the joint undertakings such as the Halden reactor project. However, Euratom is concerned primarily and specifically with bringing about a close association in nuclear matters between the six countries which are already linked in the European Common Market and the Coal and Steel Community, and which are thus moving progressively towards closer integration. ENEA, on the other hand, is concerned with cooperation between all European countries.



National power programmes
—a world survey

Economic nuclear power will come much sooner in some countries than in others but it is now possible to build up a general picture of the world situation. In this country-by-country review a specially-commissioned team of economists and technical experts trace the probable pattern of development and outline current plans

The economic background

The second Geneva Conference on the Peaceful Uses of Atomic Energy held in September, 1958, and the sectional meeting of the World Power Conference, held at the same time in Montreal, have together made it possible to get a much better idea of different countries' nuclear power programmes. This review article is designed to indicate what these programmes are and to relate them to each country's economic and geographical conditions, while at the same time measuring the amount of supporting effort being put into nuclear energy research and development.

That nuclear power must be used, and used soon, no one can deny; the problem is precisely when and in what form. The world will probably be consuming between two and three times as much energy in the year 2000 as it does now. Although conventional fuel reserves, when looked at on a world basis, are adequate, they are badly placed as far as the present largest fuel users are concerned. And the cost of getting this energy out is steadily getting higher and higher.

Before discussing each country's problems individually, it is appropriate in this introduction to try and bring out some of the factors any government thinking of going in for a nuclear power programme for the first time must bear in mind. The actual cost of nuclear power is not discussed; a great deal has been written on that intricate subject already; the points made are those which emphasize the difference between nuclear and conventional power from an economist's, rather than a cost accountant's, point of view.

Size and nature of demand

Nuclear energy is a capital intensive form of generating electricity, as opposed to conventional thermal power, which is running cost intensive. This means that, in order to minimize total costs per unit generated, it is even more important that nuclear power stations should be run at a higher utilization or load factor than it is that conventional thermal stations should be.

The economies of scale of production, combined with the importance of capital costs in total costs, make large generating units specially attractive.

These two considerations make it highly desirable that a nuclear power station should be built to meet a demand that is large and continuous. Fortunately, it seems that these two considerations are becoming less rigorous than they used to be; capital costs are falling and are expected to continue to do so. Nevertheless, these two conditions will continue to be important in most countries until the capital cost of nuclear power stations has fallen to a level approaching that of conventional thermal stations (say £50 per kW). This is a long way off yet; the lowest capital costs yet seriously mooted for a nuclear power station are still 50% above conventional thermal power capital costs, and economies of scale will continue to be of importance.

Until capital costs fall in this way there will continue to be a premium on large inter-connected networks. Assuming a reactor size of 100 MWe, a 25% base load, and a willingness, on system operations grounds, to accept nuclear coverage of half of it, then the minimum network size for incorporating a nuclear power station would be 800 MW. There are at the moment few such demands; they are all to be found in Western Europe, North America, parts of the Soviet Union, and Japan. With the rapid increase in demand for electricity in all parts of the world, and the technical advances in reactor design expected in the next few years, this limitation on the scope of nuclear power should disappear.

Many countries, and in particular the low-income ones, have to be careful about the effect of having a nuclear power programme on their foreign exchange position. The problem is rarely, if ever, discussed in quantitative terms; it is usually mixed up with a number of other considerations—all tending to national autarky—such as the full exploitation of local nuclear fuel reserves.

Balance of payment considerations

If the choice were between two ways of producing electricity neither of which depended at all on local resources, then price considerations would be the determining ones. Some countries, though not in exactly this position, are faced with a closely similar state of affairs; all fuel has to be imported together with the majority of the generating station, only the civil engineering being done locally. In these circumstances, countries have, from the balance of payments point of view, a distinct incentive to switch to nuclear power as soon as nuclear costs per unit generated approach conventional costs. Capital costs form a higher proportion of total costs in a nuclear than in a conventional station. Therefore, since nuclear civil engineering costs form at least as large a part of total capital costs as do conventional civil engineering costs, the import content of nuclear electricity will be less than the import content of conventional electricity. On the other hand, though, it will have to be paid for earlier; this need not be a disadvantage if additional capital can be made available by international lending. It should be noted that the import content argument does not apply to hydroelectricity which, with its high civil engineering cost proportion of total cost, seems ideally suited to a low labour-cost country.

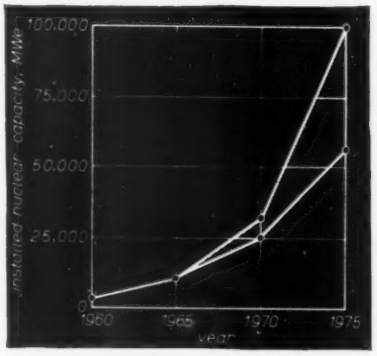
Finally, for truly international trade-minded countries, there is the further problem as to whether it pays better to invest in export industries or import-saving industries. In the present context this might mean either importing a nuclear power station and paying for it by increasing exports or, say, investing in internal transport to use national but inconveniently located resources. Such considerations are very rarely of importance in the world today, though they are relevant to quite a number of countries such as India and, in the transport context, the Soviet Union.

The rate of introduction of nuclear power depends also on a number of criteria which are not precisely measurable in money terms.

If a country is thinking of importing a nuclear power station, specialized engineers are required to help the generating authorities write out their specifications for manufacturers to tender to. They are wanted to help coordinate construction and, finally, they are wanted to run the stations when they are built. Most countries that are thinking in terms of having a nuclear power programme are already having these engineers trained, usually in the USA or the UK. It is important that they should be well trained, not least because it will help avoid costly errors in programming. It is interesting to see that the NPPC—AGIP Nucleare agreement made provision for training. This is a valuable service for a country or a company just coming into the business.

Manpower and safety

Closely connected with making sure that skilled men are available at the right time is the problem of safe operation. Atomic energy is still so closely connected in the public's mind with weapons of destruction, that any minor mishap receives the amount of publicity which, in another industry,



PROGNOSIS Estimates of installed nuclear generating capacity for non-communist countries range between 60,000 and 100,000 megawatts by 1975

is reserved occasionally for a major disaster. The coal mines in the UK kill, on the average, over 300 people a year: atomic energy has so far not killed one by radiation. The radiation record in the USA is excellent, and there is no reason to believe that it is any worse in the Soviet Union.

A grave accident has unfortunately occurred in a country which is only just starting on a research programme—Yugoslavia. One person has died so far and five others are seriously ill. Yugoslavia is by no means a backward country: her ability to construct and operate a zero energy assembly shows that. But it does seem that mistakes were made, and that these were due in part at least to the inadequate knowledge of people allowed to run the reactor. It becomes doubly important for the future of the industry, therefore, that operators are trained up to the standards which have so far prevented any comparable disasters in other countries.

Research and development

Perhaps the most difficult decision to take at the moment is how much money it is worth spending on research and development in nuclear energy. Late starters have the advantage of having access to the results of at least a part of other people's work, but countries capable of sustaining a nuclear energy industry are generally those that will want nuclear power the earliest; consequently, they have the least incentive to wait. At the moment differences in individual countries' levels of nuclear knowledge are being eroded away: the change since the first Geneva conference is quite noticeable.

The years ahead

The country by country surveys which follow show up a broad general pattern springing from the operation in each country of the various considerations outlined above.

The countries which have been first to inaugurate substantial nuclear power programmes are those industrialized economies which are either entirely without fossil fuel reserves (Italy and Japan), or whose energy reserves are insufficient (France, UK). These countries all plan to have nuclear capacity in operation by 1965, about 10,000 MW in Western Europe and 600 MW in Japan. During the following five years the energy position of a number of countries will have deteriorated sufficiently *vis à vis* increasing demands for them to be considering introducing nuclear power. By then, too, ideas will be much more precise as to how much nuclear power is likely to cost in different parts of the world.

The years 1965–70, then will not only see the US programme getting under way, but will see nuclear power stations going up in a number of smaller countries whose base load demand by then will have increased sufficiently to justify their building a nuclear power station (e.g. Finland, Taiwan). It will only be in the 1970's that nuclear power will have started making substantial inroads into the domain of conventional power. By 1975 there might well be anything between 60,000 and 100,000 MW of nuclear power installed (excluding the Soviet bloc), depending on how attractive economically it turns out to be.

THE MAJOR ATOMIC COUNTRIES

United States

Forecasts of US energy consumption over the next 15–25 years have varied with their assumptions about (i) growth of the economy; (ii) changes in the industrial structure; (iii) scope for better fuel utilization.

In consequence, extensions of these techniques to forecasts of electricity consumption, and the proportion which could be generated by nuclear power have been even more diverse.

Halving nuclear costs

There is, however, increasing agreement on the broad proposition that nuclear generating costs can be expected to halve—to around 6/7 mills/kWh—overhauling by 1975/80 conventional costs handicapped by rising fuel prices. Before 1970, nuclear power is unlikely to be economic except in areas with high conventional fuel costs, notably New England and the upper Mississippi basin region. After 1975, perhaps half (in some areas, all) power stations built will be nuclear, the main exception being the cheap hydroelectricity region of the Pacific North-West.

The effort deployed on reactor development in the United States is on a scale designed to these objectives, and takes full advantage of:

TABLE 1 US FORECASTS OF ELECTRICITY UTILITIES GENERATING CAPACITY IN 1980 (1000's MW)

FORECASTER	TOTAL	NUCLEAR	NUCLEAR %	NUCLEAR % OF 1975–1980 INSTALLATIONS
A	285	42	15	28
B	500	175	35	65
C	370–600	54–138	15–23	52–55
D	700	227	32	60
*E**	324	58	18	76

**includes industrial capacity*

1. the steady accumulation of basic information and operational experience since 1942

2. cheap U-235 from large plants geared to US defence requirements

3. relative freedom at present from conventional fuel shortages (one estimate sets the critical period at 15–20 years for some fuels, and inside 30 years for the rest)

4. the massive technological resources available.

At the end of June 1958, four large prototype civil reactors were being built, and a further eight were planned under the first stage programme:

These thirteen reactors, with a total planned capacity of about 1000 MWe, were backed by ten working reactor experiments, with a further four on the way (73 military, propulsion etc power reactors or experiments are also built, building or planned).

The expected net electricity capacity of the civil stations and reactor experiments working by 1963 is expected to rise as shown below:

	1957	*1958*	*1959*
MWe	72	78	78
1960	*1961*	*1962*	*1963*
384	827	1131	1327

This development is largely within the framework of the Power Reactor Demonstration Programme of the US Atomic Energy Commission. Since 1953, when the first stage of the PRDP began, AEC's annual expenditure on civil power projects (including development assistance) has risen from $M25 to $M95.

Second stage now planning

The AEC's plan for the second 5–7 year stage of the Programme is under discussion. The Commission propose to continue to direct and finance general reactor research and development, and to secure the execution of twenty-one design studies for a dozen distinct reactor systems, half of the most promising (or a total of about 1000 MWe actually to be constructed for completion in 1963–1968. Industry will be offered free or cheap nuclear material and research facilities and assistance, the AEC standing ready to place direct contracts for any part of the programme not otherwise undertaken.

This stage aims at reductions in capital and fuel costs, both of which are higher than expected in the Shippingport PWR. Particular emphasis is placed on the need for improvements in fuel element metallurgy, plutonium utilization, uranium oxide fuel and breeding. The AEC's basic research and development costs will rise to $M125–150 a year; research and development directly in support of the programme will cost an additional $M125 a year, part of which should be borne by industry.

Enthusiasm for BWR

An AEC paper presented at Geneva high-lighted some of the most promising systems (Table III).

Enthusiasm for the BWR, as a system capable of low capital and fuel costs, was stressed at Geneva and encouraged by the award of the Italian SENN contract to the General Electric Co, who have since proposed a $M128 development expenditure to culminate in 2000 MWe of economic plant. Although nuclear-superheating, dual steam/water circulation to provide control of instability, and fuel discharge arrangements pose difficult problems the target of 6·5 mills/kWh by 1970 is by no means visionary. Commonwealth Edison's GE-built Dresden reactor, which should start up next year, is in fact designed to produce 7·5 mills power—no more expensive than that from Edison's coal-fired plants.

The PWR system, on the other hand, originally developed regardless of cost for military propulsion purposes, may already be pushing against limitations of size; the 200 MWe design study in the second stage programme—for which 26 US firms are in the field—will reveal whether the very high fuel ratings and pressure vessel thickness necessary in larger PWRS can be expected. It seems more likely that the PWR and BWR concepts will coalesce into a dual cycle system sharing the advantages of both.

Operating experience with the Organic Moderated Reactor Experiment—which was specifically designed to maximize the problem of, and test arrangements for dealing with polymerization of the terphenyl moderator/coolant—has shown that, with a suitable purification system, damage can be held to an acceptable limit. The Piqua reactor (No 7 in Table II) will demonstrate whether the prospective advantages of this system (no compatibility problems, negative temperature reactivity coefficient, low-pressure operation, neutron economy) can be realized at the low capital costs expected.

The fourth short-term system of

TABLE II US CIVIL PROTOTYPE REACTORS

	SHORT TITLE	TYPE	MW(e)	STARTUP	REMARKS
Built					
1.	*Shippingport*	PWR	60	1957	later cores < 100 MW(e)
Building					
2.	*Dresden*	BWR	180	1959	
3.	*Indian Point*	PWR	255	1960	inc. 104 MW(e) oil-fired superheat
4.	*Enrico Fermi*	Fast breeder	90	1960	later cores < 150 MW(e)
5.	*Yankee*	PWR	110	1960	2nd core 134 MW(e)
Planned					
6.	*Elk River*	BWR	22	1960	inc. 7 MW(e) conventional superheat
7.	*Piqua*	organic moderated	11	1961	
8.	*Hallam*	sodium graphite	75	1962	
9.	*N. States (Pathfinder)*	BWR	62	1962	inc. 16 MW(e) possible nuclear superheat
10.	*Carolina-Va*	PHWR	17	1962	
11.	*Chugach*	sodium/D_2O	10	1962	
12.	*Pacific Gas*	BWR	50–60	1962	
13.	*Florida*	gas-cooled D_2O	46	1963	

All the above except 2, 3 and 12 are part of the AEC's Power Reactor Demonstration Programme

Table III is the gas-cooled, graphite-moderated reactor. A full reactor design study was carried out at Oak Ridge in 1945, and in more recent years there have been further design and initial development studies. It is now proposed to consider construction by 1962 of a 40 MWe reactor burning partially enriched uranium oxide fuel clad in beryllium or stainless steel, cooled by carbon dioxide or helium and with an outlet gas temperature of 1000 deg F. This specification is about the same as that projected for the advanced gas-cooled reactor prototype now under construction in the United Kingdom. More advanced concepts, corresponding to the UK high temperature reactor experiment, are also being studied.

Economic demonstration

The electric utility companies, which provide 80% of US consumption, are undertaking the major part of the finance of nine of the first stage reactors (all except Nos 6, 7, 8 and 11), at a total cost to them of some $M520. The companies have combined under the auspices of the Edison Electric Institute to 'study and appraise on a continuing basis the technical and economic factors relating to the development of nuclear power . . .'

It is perhaps significant that, despite unforeseen losses and set-backs, they continue to feel that exploration of every promising avenue should continue, and that concentration on a few reactor types would be premature.

Not unnaturally, however, the bulk of their financial support has been given to pressurized or boiling water reactors, for economic or near-economic projects, although the Santa Susana (10 MWe sodium graphite), Enrico Fermi and the proposed Pennsylvania reactors are evidence of faith in the future of advanced systems.

The US reactor programme is aimed at the demonstration of economic generation in high fuel cost areas by the simpler reactor systems in the mid-1960s, and in low fuel cost areas by more complex breeder systems during the following five years.

TABLE III US PROJECTED SYSTEMS

SHORT TERM (FOR 1966)	
PWR BWR *Organic-cooled* *Gas-cooled*	Systems promising competitive costs in dear coal areas
LONG TERM (FOR 1970 AND BEYOND)	
Homogeneous Thermal breeder *Fast breeder*	Systems suitable for cheap coal areas; plutonium breeding or re-cycling

This programme is divided into two stages. Stations built by 1963 will have a capacity of about 1000 MW, and the second stage stations will roughly double this by 1968.

The AEC will undertake all necessary basic research, and provide facilities, fuel and other assistance to industry: the AEC will also finance design or construction of any reactor system in the programme for which industry has not made satisfactory proposals.

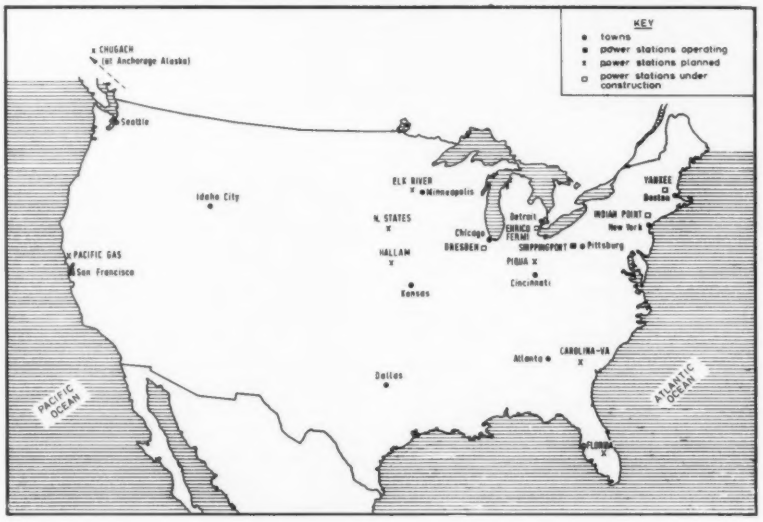
The catalogue of reactor systems under study is now so lengthy that the research and development resources of the AEC and US industry will be strained to their limit. Much work is already under way to reduce the costs of Commission processing plants. Moreover, UK experience has shown that development of economic fuel elements itself demands an effort which increases rapidly in the period before production design is finalized.

In the UK, work on several systems (eg sodium graphite, homogeneous, organic) now under study in the USA has been cut back to basic research because the effort needed to exploit them was not available. Even the much greater resources of the USA may be insufficient for the AEC's multifarious policy.

Fuel plan needed soon

Although present policy stimulates private effort and investment, there is a consequential risk that the vested interests of manufacturers or utlilities will impede the rational selection of a few reactor systems for large-scale adoption.

If nuclear generation is to relieve pressure on fuel supplies, there should be a rapid increase in nuclear construction in the 1970s. It will be essential soon to plan for a *national* balance then between fissionable fuel (plutonium and uranium) supplies and the requirements of the various systems. The AEC programme leaves little time for this to be done.



The Soviet Union

The nuclear power programme in the USSR is, in its early stages at least, the largest of any; 2000–2500 MW by the end of 1960. The programme is of particular interest in two of its main aspects; firstly, it is being developed in a country well endowed with natural fuel resources — hydro, coal and oil—and, secondly, the programme shows an interesting compromise between America's broad front attack and Britain's intense development of one main system.

Some sort of intermediate path would seem to be indicated by the economic and geographical conditions in the Soviet Union. The economy is expanding at a rate unparalleled in any country of comparable size and this growth, being centred in the basic industrial sector, is especially remarkable in the electricity supply industry.

Why nuclear power is needed

Both production and capacity have been just about doubling every five years since the war, compared with about every ten years in the UK. It is interesting to note exactly how far production is oriented towards the industrial sector. Of the 170 × 10^9 kWh produced in 1955, 76% went to industry and 2% to transport, leaving after losses, 19% only for agricultural, commercial and domestic consumers. As a result, the average load factor in the Soviet Union is somewhat higher than in the UK; about 50% as opposed to 45%.

In the current 1955–60 Five Year plan, generating capacity expansion emphasis is being shifted towards hydroelectricity. The average annual increase in hydro output is planned to be over 30% p.a., while thermal plant output will going up by a relatively meagre 15% p.a. At the moment, the bulk of the electricity supply comes from thermal stations. Thermal generating capacity in 1955 was 30,500 MW, while hydro capacity was only 6400 MW. By 1960, this disparity will have been reduced; thermal capacity will have been almost doubled to 57,700 MW, but hydro capacity will, during the same period, have been almost trebled to 17,300 MW. Even by then, however, the bulk of the supply will still be coming from thermal stations.

A glance at the map will show why this is, and why nuclear power is so attractive despite the large amounts of untapped hydro reserve. The principal coal-producing areas are not always placed conveniently near centres of electricity demand; the rivers capable of being used effectively for producing hydroelectricicty are, if anything, even less so. This applies in particular to the older industrialized areas in European Russia; the Leningrad and Moscow areas, and the area south of Moscow which is still inconveniently far away from the Donbass coalfield, together with the newer industrialized areas in the southern Urals, centred on Sverdlovsk and Magnitogorsk. This latter area, though rich in iron ore and in many other useful metallic ores is deficient in coal; the nearest coalfieds—Karaganda and Kuznetsk — are 1000 and 1500 miles away respectively. In these circumstances nuclear power stations might well prove themselves to be attractive economically within the next decade or so.

Similarly, although the known workable hydro reserves are immense —equivalent to 137,000 MW of capacity—they are not, for the most part, in the right part of the country.

The present Five Year Plan reckons on installing 2000 to 2500 MW of nuclear generating capacity by the end of 1960. At the time of writing no information about post-1960 plans was available, though the recently announced 1960–1965 and 1965–1972/73 plans should soon provide some more details about the longer term programme.

SOVIET ELECTRICITY GENERATING CAPACITY AND PRODUCTION

*Planned	1917	1940	1942	1945	1955	1960*	1965*	1972/73*
Capacity (MW)	1000	11,000	n.a.	10,700	36,900	75,000	n.a.	n.a.
Production (kWh × 10^9)	2	48	29	43	170	320	510	900

On the published information, it seems unlikely that the present nuclear programme will be fulfilled. So far 105 MW of capacity has been installed: 5 MW at Obninsk, near Moscow (the 1954 power station) and 100 MW in Siberia. There are three large stations now under construction: a 420 MW, two-reactor PWR at Voronezh, a 400 MW, four reactor enriched uranium, graphite-moderated, water-cooled station at Beloyarsk in the Urals and a 500 MW continuation of the Siberian graphite-moderated, natural-uranium water-cooled plant to make up its full complement of six reactors. An additional two stations in the 400–600 MW range are to be built, five in all, to bring the total up to the Plan programme. One of these, also a 420 MW two-reactor PWR, will be built in the Leningrad area. It is not yet known where the remaining station is to be; possibly it will be in the Moscow area. It was also planned to include an experimental fast reactor 250 MWe station in the current Five Year Plan, but it now looks as though the development of this reactor system is taking somewhat longer than was at one time hoped.

The programme is being completed by building a number of reactor prototypes of about 50 MWe. All of these will be at the Ulyanovsk Reactor Testing Station. A 50 MWe BWR and a 35 MWt homogeneous heavy-water uranium oxide reactor are now being built. A 50 MWe fast reactor will be built there as soon as enough data is obtained from the 5 MWt reactor experiment which went critical earlier this year. Finally, work is going ahead on a 50 MWe sodium graphite prototype.

It is unlikely that all of these reactors will be in operation by the end of 1960; the 50 MWe BWR, for one, is not now scheduled for completion before 1960. However, given the known Russian ability to build reactors quickly and efficiently and their repeated declarations of their intention to fulfil the Five Year Plan as far as nuclear power stations are concerned, it would be unwise to assume that, because in many respects the amount of freely available information falls short of what one would expect from such a technically advanced nation, the Soviet Union will not have its 2000–2500 MW of nuclear generating capacity installed by 1960.

Power for the Urals

The location of these stations follows the logic of the supply of and demand for electricity outlined above. The Voronezh power station is ideally located on the river Don, halfway along the new high voltage transmission line from Stalingrad to Moscow, yet sufficiently far away from the Donbass to be effective economically. Voronezh itself is a thriving industrial town, though not one capable of absorbing the full 420 MW generated.

The most rapid build-up of nuclear power, however, is in the southern Urals. Besides the 400 MW enriched uranium graphite-moderated station, the new 100 MW first stage of the 600 MW natural uranium graphite-moderated station is almost certainly in a position to supply this region, which, of all the rapidly developing

industrial areas, is most likely to run into an aggravated power deficit fairly soon.

No Moscow station

The only site which is perhaps slightly surprising is the one near Leningrad. Although it is true that the city is very badly placed, both for hydro power and fossil fuel supplies, it is nevertheless, by current Soviet standards, a small and slowly developing area poorly endowed with transmission facilities. Demand in 1960 is unlikely to exceed 2000 MW, and building even a two-reactor station to take care of the entire base load seems to be taking a risk. On the other hand, it might well be that the base load in that area forms a higher proportion of total demand than is usual in Western Europe; this seems to be the case in Moscow and, indeed, judging by the higher system load factor might well be the case in most other industrial areas too.

The Ulyanovsk site too, through primarily a testing centre, is well situated for sending out the electricity generated there. It is quite near one end of a 400 kV transmission line running from the middle Volga to Moscow.

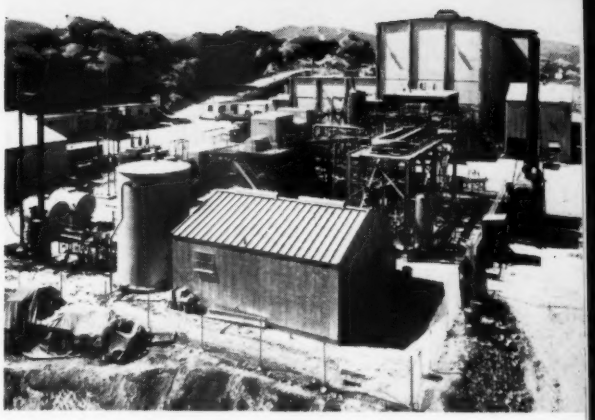
The lack of a station near Moscow seems remarkable; one was announced some time ago but no site has been mentioned, though there are plenty available within a comfortable distance with good cooling water and transmission facilities.

Emphasis has so far been firmly placed on water-cooled systems, firstly the uranium-graphite system and secondly the PWR system. This development corresponded to the Russian need to build up a bomb potential and to go in for marine propulsion. The water-cooled version of the uranium-graphite system has the advantage of higher heat ratings than the gas-cooled version, and the PWR is well suited for marine propulsion due to its compactness. It is being used in the ice-breaker *Lenin*.

Move towards boiling

The largest power station, the 600 MWe Siberian plant, runs on aluminium-canned natural uranium. The thermal efficiency is low—20 to 25 %—for the same reason as in Calder; steam conditions are bad — temperature only 180° C—because presumably the reactor will have been optimized for plutonium production. The cost of electricity from this plant, with an unknown plutonium credit, is about 20–25 mills; the national average is about 20 mills at official exchange rates.

United States

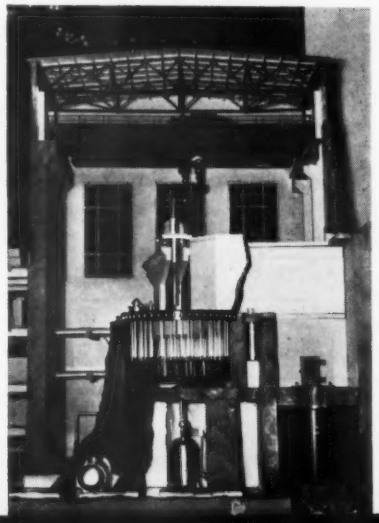


Sodium Reactor Experiment in the Santa Susana mountains near Los Angeles is the only sodium-cooled power prototype in operation in the world. Built by Atomics International, it has been producing 6 MWe since 1957

Successful results with Argonne's Experimental Boiling Water Reactor — shortly to be upped to 100 MWt—has been largely responsible for the growing interest in BWR's in the US and elsewhere. EBWR now supplies most of ANL's power needs

Soviet Union

First non-military nuclear ship to be launched was the icebreaker 'Lenin.' Now in the last stages of fitting out, it is due to start sea trials very shortly. 'Lenin's' three PWRs are probably submarine units



Part of Russia's ambitious fast reactor programme, the 50 MWe BN-50 will be plutonium-fuelled and sodium-cooled. When it is completed, construction on a 250 MWe station will begin

The system used in the first nuclear power station has been further developed. Based on the Obninsk plant, the 400 MW water-cooled graphite-moderated station at Beloyarsk is designed to recirculate steam, which has been separated outside the reactor from the primary circuit, back through the reactor to superheat it. In this way steam temperatures will be raised from about 300° C to up to 500°C.

On the water moderated side, the move is away from the original PWRs towards BWRs. This follows naturally as the emphasis is gradually turned from propulsion to producing cheap power. The 50 MWe prototype at Ulyanovsk marks a stage in this transition; the PWR fuel elements now being made for the Voronezh station will, with only minor adaptations, be used in this reactor as well.

As a longer term solution to their energy problem the Russians have been turning increasingly to fast reactors. The programme started fairly late with a very simple reactor in 1955 but has been gathering momentum.

BR-5, which started operating at Obninsk in July of this year is the most powerful un-moderated assembly now working. Work on fast reactors, which is now entering the phase when engineering problems become more important than physics problems, is largely being transferred to the Reactor Testing Station at Ulyanovsk.

All work on nuclear power is under the control of the Central Organization for Atomic Energy, whose head is Academician V. S. Emelianov. This organization used to report to the Prime Minister, Bulganin, directly; it is not clear who it reports to now. The Ministry of Power Stations is responsible for seeing that the Five Year Plan is fulfilled, though they will select reactor types on the advice of the Central Organization for Atomic Energy. The stations themselves are constructed by yet another Ministry, the Ministry of Power Station Construction. It should be remembered that not all power stations are run by the Ministry of Power Stations; about a third are run by other industrial ministries. Other projects might involve yet other ministries, e.g. the ice-breaker project was largely under the control of the Ministry of Shipping.

Research is still mainly centred in the Moscow area though, with the passing of reactor systems into the engineering stage, more work will be concentrated at Ulyanovsk.

The Atomic Energy Institute in Moscow has been responsible for the bulk of the research work undertaken. It has three research and materials testing reactors, a large electromagnetic isotope separator and associated radiation chemistry and metallurgy hot laboratories. All the fusion work done so far has been there; Kurchatov is the director. The Institute for Heat Technology runs a 2·5 MWt heavy water research reactor and a number of machines. Most of the work there seems to be on fundamental physics.

SOVIET FAST REACTORS

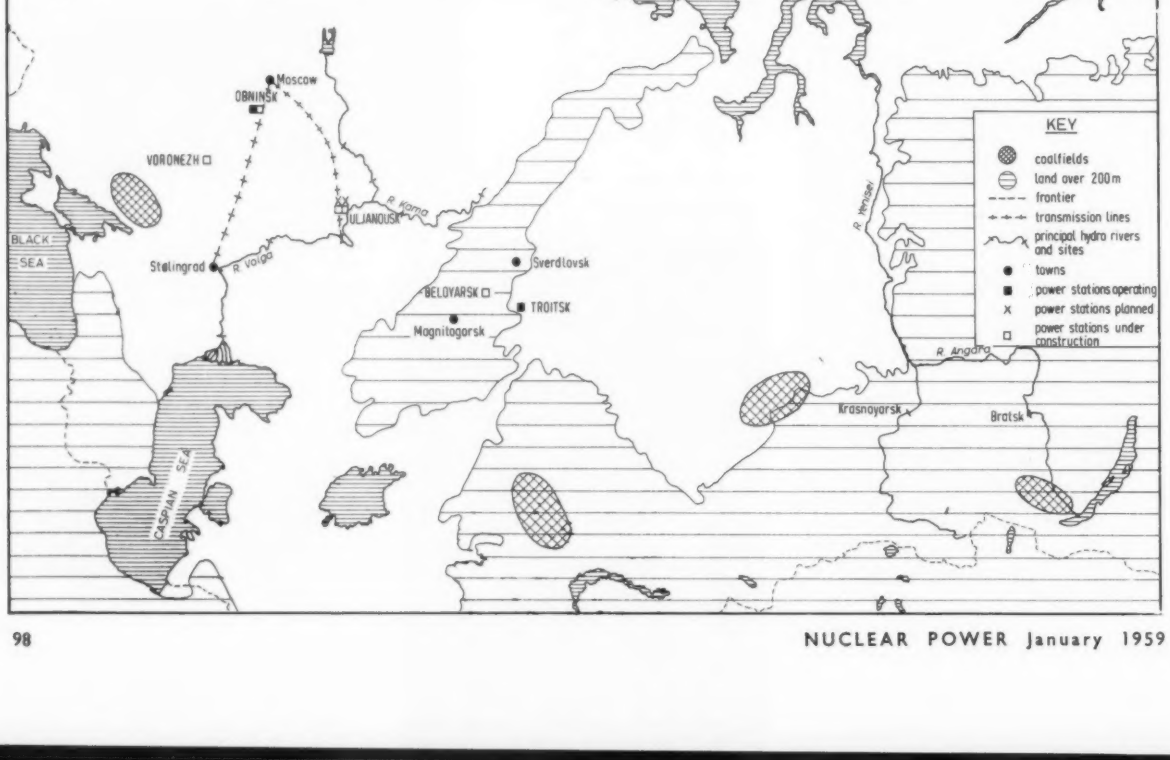
REACTOR	POWER	CRITICALITY	FUEL	COOLANT	NOTES
BR-1	zero energy	Apr 55	12 kg Pu	—	
BR-2	100 kWt	Feb 56	Pu	Hg	
BR-3	zero energy	—	Pu	—	Nat U blanket
BR-5	5 MWt	July 58	50 kg Pu	Na	rebuilt from BR-2
BN-50	50 MWe	1960/61	200 kg Pu	Na	1st charge might be U-235
BN-250	250 MWe		Pu		

Decentralized research

The station at Obninsk has been expanding more rapidly as the power programme became of increasing importance. Most of the research and development work on the graphite-moderated water-cooled route seems to have been done here. They also look after the fast reactor programme.

Finally, the Dubna research centre concentrates on the physics of high energy particles, using large machines (including the largest in the world—the 10 GeV proton synchrotron).

There are plans to decentralize quite a lot of the research work and to provide outlying centres, especially universities, with their own machines and reactors. The Institute of Physics at Moscow University already has its own research reactor and accelerators. Swimming pool reactors are going up or will soon be going up in Leningrad, Kiev, Minsk, Tiblisi, Sverdlovsk and Tomsk.



The United Kingdom

BRITAIN'S industrial economy has been built up on plentiful supplies of cheap coal. A maximum output of 289 million tons was produced in 1913 and ten years later a maximum of 100 million tons was exported but these high rates of extraction inevitably led to the working out of the most easily mined coal. Together with the growing use of oil, a reduction of output and exports resulted in the total value of fuel imports exceeding that of exports for the first time in 1936, and by 1941 Britain had become a net importer of fuels of all kinds.

It has been estimated that the continued long-term rise of industrial output at an annual rate of 3–3·5% will increase energy requirements to 290–300 million tons coal equivalent in 1965 and 360–375 million tons in 1975. Indigenous supplies are estimated to meet only about one-fifth of the increase.

The advent of nuclear power is therefore most timely for Britain. Its practical application on an industrial scale was first realized in 1956 with the opening of the world's first full-scale nuclear power station at Calder Hall. By the end of 1959 eight of these reactors—four at Calder Hall and four at Chapelcross—will be saving between them about one million tons of coal a year.

Uranium supplies can be imported mainly from the Commonwealth and the balance of payments will be greatly relieved because uranium as consumed in the first nuclear power stations (with an average irradiation of 3000 MWD/tonne) can for example be purchased in terms of energy content, at about one-fifth of the cost of imported coal priced at, say, £7 a ton. With the improvement in nuclear fuel utilization expected in more advanced reactors, the ratio would fall to perhaps as low as one twentieth.

Original programme trebled

The experience gained in designing Calder Hall showed that it should be possible to build nuclear power stations with a much greater generating capacity and able to produce electricity much more economically.

The nuclear power programme published in 1955 envisaged the commissioning of 1500-2000 MW of generating capacity by 1965 but it was stressed that the programme should be considered flexible to accommodate changes in technology or economic conditions as they occurred.

In the event, the first four stations were of double the output capacity originally envisaged. This fact, together with increasing confidence in nuclear power development and also the reappraisal of future energy supplies prompted by the Suez crisis, led the Government early in 1957 to treble the programme, with the completion of 5000-6000 MW by 1965. In addition, a 150 MW station would be built in Northern Ireland. However, a programme of this size would require the very heavy capital expenditure of £M920, including initial fuel charges, and it was not surprising that, when the Government announced measures later in that year to reduce public investment as a means of reducing domestic inflationary pressure, the programme was extended over an additional year, which was in effect delaying the completion of rather more than 1000 MW until the end of 1966. When completed, the present programme is estimated to save between 15 and 18 million tons of coal a year and it introduces a valuable element of flexibility into the supplies of energy to the national economy, which had become very dependent on two main sources of supply: the British coal-mining industry and oil from the Middle East.

1375 MW under construction

The four nuclear power stations already under construction have a total capacity of 1375 MW. They are one 275 MW station (Berkeley), two 300 MW stations (Bradwell and Hunterston) and one 500 MW station (Hinkley Point). Ministerial approval of sites has been sought or granted for a further three stations: Trawsfynydd

COST OF POWER IN THE UK	275–300 MW NUCLEAR	500 MW NUCLEAR	COAL-FIRED PLANT
	d/kWh	d/kWh	d/kWh
Capital charges, incl. charges on initial fuel	0·51–0·52	0·41–0·42	0·11
Fuel replacement costs	0·13–0·19	0·13–0·19	0·37–0·48
Works operating costs	0·06	0·05	0·05
Total generating costs	0·70–0·77	0·59–0·66	0·53–0·64

(500 MW), Dungeness (500-550 MW) and Sizewell (650 MW)—a total of 1650–1700 MW.

Generating costs of the first stations are shown in the Table. Capital costs of the first three stations (275–300 MW output capacity) are £145/kW, including site development and Electricity Board engineering charges, and that of the fourth station (500 MW), with its increased economies of scale and general engineering improvements, is £120/kW. The upper limit of fuel costs is taken at £20,000/tonne and the lower limit of the repurchase price for irradiated fuel at £5000/tonne, representing a plutonium value at about £5/gram—an irradiation of 3000 MWD/t is assumed. Some improvement in the figures may be reasonably expected with the prospect of lower cost of fuel element production and longer burn-up. Capital charges are taken at 8%, representing a 5% rate of interest, which closely corresponds to the long-term borrowing rate for the UK publicly owned Electricity Boards, and a 20-year life for the station. A load factor of 75% is assumed. A comparison with modern high efficiency coal-fired plant at a capital cost of £45/kW is provided. The appropriate depreciation period is used and typical low cost and high cost fuel sites are taken with coal at £3 13s a ton and £4 13s a ton. From the table it will be seen that, whereas the first stations in the programme have generating costs which are somewhat higher than conventional plant in high cost fuel sites, the fourth station (500 MW) should have costs about the same conventional plant. Generating costs of later Calder-type stations in the programme are expected to fall further as a result of an expected reduction of capital costs to about £100–£110/kW. At the same time the continuation of the long-term upward trend of coal prices will increase the competitive position of nuclear power.

Looking beyond 1966

No definite programme has been announced by the Government or the Electricity Boards for the construction of stations after 1966.

Nuclear generating capacity in 1975 can only be estimated over a very wide range, with a possible upper limit of 25,000 MW and a lower limit of 15,000 MW. The higher figure allows for an average annual installation of about 2000 MW between 1967 and 1975 but total new generating capacity installed each year would include some coal- or oil-fired plant for peak-load use. On the other hand, the lower figure assumes an annual commissioning of about 1000 MW of nuclear plant, which would be sufficient to take up the annual increase to the base load of about 400 MW and the remainder to operate at the higher intermediate load factors. Load factors of nuclear plant will be improved by the installation of pumped storage capacity. The above suggested range of 15,000–25,000 MW of completed nuclear generating capacity by 1975 would save between about 35 and 55 million tons of coal or coal equivalent a year.

The UK nuclear power programme is backed by a large research and development effort. Research on more advanced systems is mainly the responsibility of the Authority. The chief object of their reactor research programme is the reduction of capital costs, with the improvement of fuel utilization as a longer term objective. A major step in the development of the gas/graphite route is being taken with the study and completion of designs for the advanced gas-cooled reactor and a point has now been reached where construction has started of an experimental reactor (100 MW heat output and 28 MW electrical output). With its increased heat rating, the system offers the prospect of capital cost per kW in the range £80–£90 for large commercial stations.

Advanced reactors

In the 1970's, a further reduction in capital costs should be possible, together with lower fuel costs due to greatly increased fuel utilization. These are both characteristics of the two advanced systems on which the Authority are concentrating their long-term effort. The fast reactor should have low capital costs and provide a positive fuel breeding ratio. The reactor experiment at Dounreay (60 MWt and 15 MWe) is planned to go critical during 1959. The high temperature gas-cooled reactor also offers the prospect of low capital costs and a near fuel breeding ratio, at least. A zero-energy reactor is under construction at the Winfrith Research establishment. Both these systems will require a large and costly effort before their commercial introduction but such lengthy development, however, accords with their requirement for large amounts of fissionable material for their initial fuel charges, which will not start to become available in quantity from the early reactors in the nuclear power programme until the late 1960's. The pattern of reactor systems in the nuclear power programme likely to emerge will be governed closely by the supply and demand for fissionable material. A balanced programme of different types should be possible once a pool of material is established, with some systems drawing from it and others contributing.

Export prospects

In addition to the design and construction of complete nuclear power stations for the Electricity Boards, the UK industrial consortia are in a position to provide complete stations for overseas countries or to enter into licence agreements for the construction of nuclear plant of British designs. Construction has now started on a 200 MW station for Italy and Japan has stated that she hopes to place an order for a 150 MW station with one of the consortia in 1959. UK firms also plan to provide small nuclear power plants and two of them have made agreements with US firms for the provision of small nuclear power stations with outputs in the range 2–25 MW. Unlike the larger stations built exclusively by UK firms, these smaller stations will require enriched uranium fuel. Medium-sized reactors of British design are one of the objectives of the Atomic Energy Authority's reactor research programme. These may also be capable of use as propulsion units for ships.

Benefits soon

Britain is now engaged upon the implementation of the largest programme of commercial nuclear power to be undertaken in any country in the world. Because of her particular energy position, Britain is likely to draw upon the benefits of atomic power more quickly than most countries. The rate at which this takes place will depend on many factors, of which among the most vital will be the success of the research and development effort taking place now and in the next few years.

France

IN MANY of its aspects the French nuclear energy programme resembles that in the UK, the economic and technical positions of the two countries being qualitatively, though not quantitatively, comparable. Both countries found themselves after the war denied access to US information and both decided that their continued existence as first-rate powers with world-wide responsibilities required the development of an atomic energy industry, either for military or for civil ends, or for both.

Natural uranium route

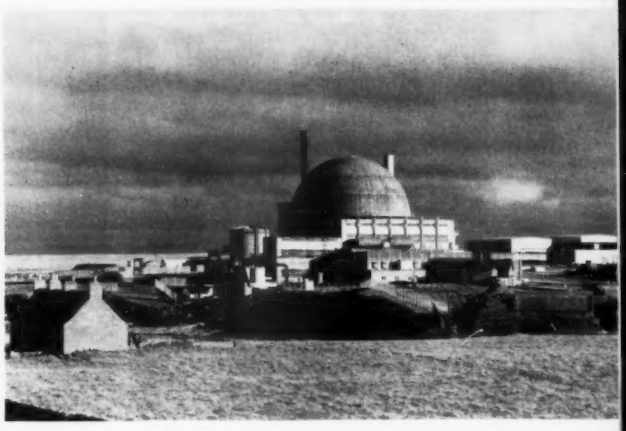
In France immediately after the war, priority had to be given to reconstructing a badly damaged country and to repairing the effects of isolation from scientific and technical development during a crucial five years. It was not until 1948, therefore, that ZOE, a heavy water research reactor, went into operation at Châtillon. The facts that the production of both enriched uranium and heavy water require the construction of large and costly factories led the French CEA Commissariat à l'Energie Atomique) to choose the natural uranium graphite-moderator route. The high cost of electric power in both Britain and France militated further against the use of enriched uranium. The discovery of uranium bearing ores in metropolitan France has put more drive behind this type of programme.

Unlike the UK, however, France has sufficient reserves of hydro power to last another 15 to 20 years, though her coal industry is smaller. France is already importing about 40% of her energy. On balance the problem facing the two countries is much the same: it is to provide a source of energy for the future which does not depend heavily, both from the security and commercial points of view, on foreign countries.

Aim is self-sufficiency

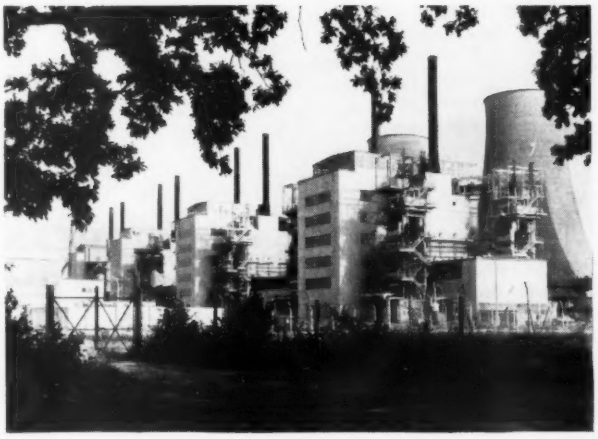
This objective is reinforced by a long tradition of economic self-sufficiency which shows itself in a distrust of relying permanently on foreign supplies of any national necessities, whether it be food in the form of American wheat, or energy in the form of Middle East oil. This attitude has its counterpart in a reluctance to commit themselves too heavily in the export market.

This all means that we might expect France to develop a nuclear energy industry specially adapted to French



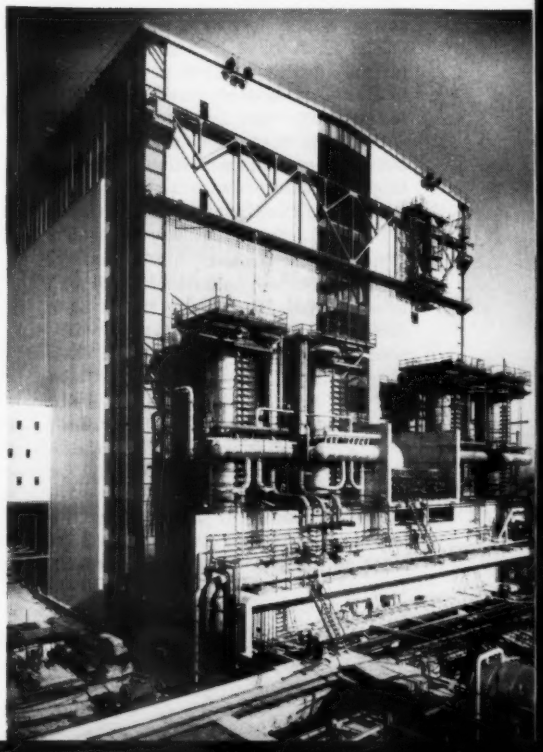
Now familiar outline on the north coast of Scotland is the Dounreay Fast Breeder Reactor, due critical early in 1959. Further to the left is the Dounreay Materials Testing Reactor in its cylindrical building—it started up a few months ago

United Kingdom



The four graphite-moderated reactors of Chapelcross power station are identical to Calder Hall. By the end of 1959 the two stations together will be supplying 280 MWe to the national grid, saving the country about a million tons of coal a year

France



First full-scale power reactor to go critical in a programme similar in many ways to Britain's was the CEA's G2 at Marcoule, output 30 MWe. Identical twin G3 is nearing completion. Like the early British stations, the Marcoule reactors also produce plutonium

domestic needs: it will have little regard for the export market and there will probably also be a complete exclusion of foreign competition from the domestic market.

Comparison with UK programme

By 1965 nuclear energy will be producing 5%, by 1970, 12% and by 1975, 30% of total electricity generated. The programme measured in this way is smaller than the one in the UK, but France will still be using up her hydro and natural gas resources during this period. The rate of development in the first critical years—when the prototype stations are being designed—is markedly lower, though electrical output per reactor, being a rough indicator of the technical level reached, will be about the same.

NET ELECTRICAL OUTPUT OF LARGEST REACTOR IN OPERATION

	FRANCE		UNITED KINGDOM	
1956	G-I	5 MW (gross)	Calder Hall	35 MW
1958	G-II & G-III	30 MW		
1959	EDF-I	63 MW		
1960			Bradwell	150 MW
1961	EDF-II	167–210 MW		
1962			Hinkley Point	250 MW

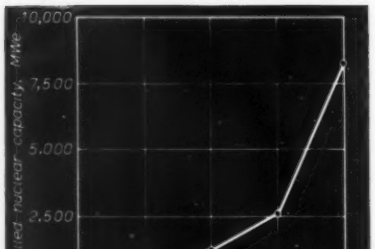
EDF-I appears as an extra stage, compared with the UK programme, inserted between G-II and G-III, which compare with Calder Hall, and the first round of civil power stations; EDF-II, being a one reactor station, will be larger than these in reactor size, though smaller in electrical output. This insertion of an extra stage is an indication of the French ability to take things more easily due to their having a somewhat simpler energy supply problem to resolve.

The CEA have not indicated how far they intend to develop the natural uranium, gas-cooled, graphite-moderated reactor; they content themselves with saying that the future is obscure but that present indications are that larger reactors with higher heat ratings are the thing to go for.

Diffusion plant planned

The CEA are understood to intend to start work in the near future on a 350 ton/annum diffusion plant, capable of enriching up to 4% U-235. This will cost about £M40 and will use 100 MW of electricity. It is not clear how this will fit into the French programme although one use of the enriched uranium produced will be for naval propulsion.

France, however, suffers from the same difficulties in reactor development as the UK though to a greater extent. There just are not the resources available to go into all the reactor systems that look promising. Attention has to be concentrated on two or perhaps three routes only, and many of the 'fancy' systems have had to be dropped. The CEA now employ about 9000 people in their research and production establishments, compared to over 30,000 in the UKAEA, and spend over £M80 a year.



France intends to step up the installation rate in 1965 and again in 1970, reaching about 8000 MW by 1975

As a result of the smaller amount of effort it can afford to put into its atomic energy industry and the need to have a fairly large programme of research to make any progress at all, France is very interested in international cooperation in research and development.

Benefits from Euratom

This state of affairs, coupled with the important political enthusiasm for some form of European integration, has encouraged France to enter into very close collaboration with its European neighbours. Euratom, with its surrender of certain aspects of national sovereignty, follows upon the success of the European Coal and Steel Community. The French are planning to build two enriched uranium reactors under the US-Euratom 1000 MW power demonstration programme. It is too early yet to see how the French are going to reconcile their desire to use their atomic energy industry as an instrument of national prestige with their desire to make a success of their nuclear energy programme.

EUROPEAN COUNTRIES

Austria

The reactor programme of the Austrian Study Group (comprising Government, public and private industrial shareholders) initiated in May 1956, provides for:

(i) a 5 MW swimming pool reactor, now building, followed by
(ii) a university training reactor;
(iii) an MTR
(iv) a protoype power reactor.

Of hydro resources estimated at 40,000 million kWh, the quarter which is exploited, accounted for 8,661 of 11,718 milion kWh produced in 1956. Exports of electricity are substantial, notably to Germany.

Whilst there appears to be no general prospect of economic nuclear power for at least a decade, nuclear stations might supply bulk demand in eastern areas remote from hydro stations. Industry could produce graphite, aluminium and special metals.

Belgium

Energy requirements for Belgium's industrialized economy have greatly expanded since the war and electricity output has risen by 7% p.a. in the years 1953–57. Coal is virtually the only indigenous source of energy; total hydro-electricity capacity amounts to only 56 MW and there is no oil.

Future energy requirements are estimated to exceed domestic production by 10–14 million tons in coal equivalent in 1965 and 22–25 million tons in 1975, assuming a high rate (5% pa) of increase in industrial output. If only a 2% annual increase is assumed, the deficit is expected to be 0·5–4 million tons tons coal equivalent both in 1965 and 1975. Coal production, now running at about 30 million tons a year, is estimated to increase only to 30–34 million tons in 1965 and 33–37 million tons in 1975. The deficit in energy requirements will have to be met by imports, mainly of oil, or with nuclear power as an increasingly important alternative. The exploitation of the very important uranium resources of the Belgian Congo during and since the war lent early interest in the potentialities of nuclear power.

In Belgium, a number of organizations concerned with the development of nuclear energy have been set up. The Commissariat à l'Energie Atomique is the governmental body, which was established in 1950, to liaise with these organizations and with foreign governments. The Centre d'Etudes de l'Energie Nucléaire (CEN), formerly CEAN and reconstituted in 1957, is concerned with applied nuclear

research. It is financed partly by the Government but industry is expected to provide an increasing contribution. It has an extensive research centre at Mol. Its first reactor BR-1, a 3 MW air-cooled natural uranium reactor similar to BEPO in the UK, went into operation in 1956. A 25 MW materials testing reactor is planned for completion in 1959 with US assistance. The third reactor at Mol is a 11·5 MWe pressurized water reactor built by Westinghouse and also due to come into operation in 1960.

A company — Belgonucléaire — has been set up by a number of Belgian firms, mainly engaged in heavy industry, as an organization concerned with the practical application of nuclear power, the design of nuclear generating stations and the production and processing of fuel elements.

No official statement has so far been made on the Belgian nuclear power programme but it is understood that the installation is envisaged of four large power reactors of different types and with a total output of 550 MW by 1967. Total nuclear capacity installed by 1975 has been estimated at 1800 MW.

Generating costs of modern base load conventional plant would appear to be in the range 43–66 centimes a kWh (0·6–0·9d)—generating costs are not published by supply undertakings. Nuclear capacity will be assisted by the large amount of interconnexion. Normal capital charges amount to about 12%. Over 90% of the present 4000 MW generating capacity in Belgium is owned by private undertakings or by industry.

Belgium is also concerned with certain other major nuclear developments. A site has been selected at Mol for the proposed OEEC chemical processing plant—Eurochemic.

Denmark

Denmark has virtually no natural fuel resources. A rising proportion, now around 20%, of expenditure available for imports has to be spent on solid fuel and petroleum products; electricity generation accounts for roughly the same proportion of total fuel imports. Moreover, electricity consumption has been increasing at 10–15% per annum—per head it is only a third of that in the United Kingdom. Load factors are low (under 40% overall, the best stations only reaching about 60%), and the thermal efficiency of major stations is only about 25%. For these reasons, generating costs are high (more than ¼d/kWh), but only if a sufficient base load demand could be stimulated could a nuclear station be economic. As there is already a seasonal exchange—with net import—by submarine cable between Zealand and Swedish hydro stations, and a net export to Germany from stations in Jutland, the foundations for a wider market already exist.

For the time being, however, the Danish Atomic Energy Commission established in 1955 is mainly occupied with building up effort at the Research Centre at Risö in the Roskilde Fjord, where three research reactors are built or building — including the British-built DR-3, a 10 MW PLUTO-type.

Work at Risö with these powerful tools benefits from Research Agreements with the UK and the USA (which is supplying research amounts of fissionable material), and is coordinated with other Scandinavian countries through the Nordic Institute for Nuclear Research in Copenhagen.

In the Society for the Industrial Use of Atomic Energy (DANATOM), electricity companies and industrialists study the design, construction and operation of nuclear power stations.

The administrative framework for nuclear power is now sketched in. As nuclear technology advances and electricity consumption improves so will the economics of nuclear power for Denmark.

Finland

Finland has neither coal nor oil and only limited hydro reserves; these will be used up in 10–15 years. The hydro power is very susceptible to drought. Quite a lot of wood is burnt—equivalent to about 2 million tons of coal. There is a considerable demand at a high load factor for process steam in the pulp and paper industry. This is not, however, often concentrated; the largest concentrated demand is for 120 tons of steam an hour. Uranium has been found in Finland.

Present installed capacity totals just over 2000 MW. Of this 1300 MW is hydro and the rest thermal.

CAPACITY AND CONSUMPTION

	1955	1960	1965	1970
Installed				
Capacity MW	1700	2700	3800	4100
Consumption				
kWh × *10⁹*	6·5	10·0	14·5	20·0

There is thus an urgent demand for nuclear power if it can prove itself competitive under Finnish conditions. Capital is, however, short and expensive, and the Finns are unwilling to risk it in any investment which is at all experimental.

Voimayhdistys Ydin—an association of Finnish firms interested in hydro power but who are increasingly turning their attention to nuclear energy—have recently constructed an experimental sub-critical assembly at the Helsinki Institute of Technology; it is light water moderated and fuelled by 1500 kg of natural uranium supplied by the UKAEA.

Federal Germany

The development of nuclear power in West Germany is governed by three important factors. Firstly is the late start due to restrictions on independent development by the Federal Republic on atomic energy in force before the Peace Treaty was signed in 1955; secondly, there is no immediately pressing energy shortage; and thirdly, there is a desire to develop the considerable potential capacity of German industry to design and build reactors and ancillary plant.

When the Peace Treaty was signed, West Germany was not well prepared to embark upon a nuclear energy project. Only a few firms, such as Degussa and Farbwerke-Hoechst AG, had made plans for the future; and past research activities on any scale had taken place only during the war or earlier, e.g. those of the Max-Planck Institute of Physics on uranium/heavy water sub-critical assemblies. However, as soon as the restrictions were lifted, the German Atomic Energy Commission was set up by the Federal Government with responsibilities to include the coordination of the activities of the various organisations undertaking nuclear research and development. In West Germany, there is no central research establishment; development is instead carried out on a decentralized basis by a number of organizations, in particular certain Land governments, universities, institutes and industrial firms.

Building a research background

One of the most urgent tasks has been the building up of research establishments and their provision with major facilities, especially research reactors. Four reactors have so far been completed, viz. the two 50 kW solution types for Frankfurt University and the City of Berlin and two pool-type reactors for Munich University and the Society for the Utilization of Atomic Energy for Shipbuilding at Hamburg. These four reactors were supplied by the United States. A 12 MW materials testing reactor of German design will be completed at Reactor Centre, Karlsruhe in 1959. A MERLIN tank-type reactor (completion in 1959) and a 10 MW DIDO-type, materials-testing reactor (completion in 1961) are being supplied by British firms for the North

Rhine Westphalia research centre at Julich. An Argonaut-type reactor has been ordered by Siemens-Schuckertwerke. The main purpose of the research programme in Germany is the provision of a broad foundation for the future development of nuclear energy and as a more immediate objective to provide sufficient trained personnel.

The time scale of power reactor development is conditioned to some extent by the comparatively favourable energy situation at the present time. There are large reserves of hard coal and brown coal and of lignite and also certain reserves of oil and natural gas and some unexploited hydro capacity. However, the future situation is expected to change rapidly. Whereas in 1954/55, total energy consumption was 188 million tons of coal or coal equivalent, of which home production was able to supply 167 million tons, total requirements for 1965 are estimated at 245 million tons. Indigenous production is not expected to increase at anything like this rate and it is estimated that fuel imports will have risen to 40 to 50 million tons of coal equivalent in 1965. In recent years, a very rapid annual increase of 11% electricity output has taken place.

Their own reactors

The tentative power reactor development programme, drawn up in 1957, is based on German-designed reactors. As no one type is considered to have emerged as a clear choice for commercial use, development is being carried out on a number of systems each of which offers the prospect of producing economic power. This work is being undertaken by industrial firms or groups of firms. At present the main effort undertaken is on the following systems:—(a) gas-cooled graphite-moderated; (b) heavy-water-moderated-and-cooled; (c) light-water-moderated-and-cooled; and (d) high-temperature gas-cooled. A further system, the organic liquid moderated reactor, is being developed in co-operation with a United States firm.

It is hoped that orders for the construction of prototypes may be placed in 1961. They will each have outputs of about 100 MWe, except the high temperature reactor which will at first be a 15 MW pilot plant (order now placed and planned for operation in 1961). It is not expected that the four or five of these prototype stations, whose development will require a very considerable effort, will be in operation before the end of 1965. Together they will have a total output capacity of about 500 MW. The orders will be placed by the electricity utilities, or groups of utilities. Final arrangements for financing the projects have not yet been completed but it seems likely that the Government will advance part of the cost by long-dated loans.

In addition to this development programme, it is intended to purchase from overseas or build under licence two or three power reactors of foreign design if this appears desirable for economic or technical reasons. A considerable interest has been shown in the Calder Hall type reactor, various enquiries have been received in Britain and tenders have now been submitted by UK consortia to RWE and to a group of electricity undertakings in Baden-Württemberg. RWE has also ordered a 15 MW boiling water reactor from the German firm of AEG with which the US General Electric Co is associated.

Economic grounds only

Construction of further stations, it was stated in the Geneva paper P/1806 submitted by Federal Germany, would be undertaken only on economic grounds, i.e. if they are competitive with conventional stations. Because of the time required for the development of prototypes, this point might not be reached until the late 1960's.

The cost figure which is the general target for economic nuclear power in West Germany is 4 pfennig (0·8d) a a kWh; this figure applies to areas mainly away from the coal fields, e.g. in Central and South Germany and the Hamburg-Hannover area. Where imported United States coal is used, the cost of conventional power is considerably higher. High capital charges, however, between 10 and 14% are unfavourable to nuclear power but the considerable interconnexion and large and growing base load are in its favour. It is at present envisaged that 6000 MW of nuclear generating capacity will be completed by 1975.

German nuclear power development may be expected to be supported by extensive ancillary plant, e.g. fuel element production and chemical processing plant.

The foundations of the German nuclear power programme are being laid and rapid development may be expected, though the effort involved will be large. The German influence upon Euratom will certainly be considerable: she is also interested in possible joint projects, in particular the provision of a joint engineering test reactor.

Italy

For many years, Italy has been increasingly dependent on imported fuels. The lack of indigenous energy resources, especially coal, has been an important factor in the development of the national economy, in particular in the preponderant growth of light industry. The chief sources of indigenous power are the very large hydro-electric resources of the Italian Alps and, to a lesser extent, those of certain areas in the Apennines. Hence, the great concentration of industry in Northern Italy. The position has, however, been somewhat improved by recent new discoveries of oil and natural gas but together they are not expected to alter the energy situation very significantly.

In his paper on *the Energy Prospects of Italy* given at the 1955 Geneva Conference, Professor Giordani estimated that total energy consumption, which had reached 44 million tons coal equivalent in 1954, would increase to 63 million tons in 1965 and 83 million tons in 1975. Electricity was expected to rise from 39% of total energy production in 1954 to 47% in 1975. Until about 1965, hydro and geothermal electricity output was expected to increase significantly to provide about 78% of total electricity production, but after that date their maximum economic utilization would have been reached.

Nuclear power, with its characteristically low fuel costs and their potentially much lower import cost content, therefore offers to Italy a particularly suitable means of reducing import costs of the additional requirements for electricity supply from 1965 onwards. They would be additional to the unavoidable imports for non-electricity purposes.

Research coordination

The Government set up the *Comitato Nazionale per le Ricerche Nucleari* (CNRN) in 1952 with the responsibilities of providing and coordinatiing fundamental and applied research, of carrying out research on reactor systems and materials and the studies of health problems. It is therefore closely concerned with the work of the National Centre for Nuclear Research at Ispra, the various universities and institutes. The responsibilities of CNRN are shortly to be extended to include, for example, the production and utilization of nuclear materials and it will then be known as the *Consiglio Nazionale Energia Nucleare* (CNEN).

The generation of electricity in Italy

is carried out mainly by private or semi-Government-owned supply utilities. Five companies have now been set up to own and operate nuclear power stations. Research is expected to continue for some time before complete nuclear stations without foreign assistance can be built and the first two orders for full scale generating plant have been placed with overseas firms.

Thus AGIP Nucleare, set up by the Government-controlled ENI group, has placed a contract with the Nuclear Power Plant Co of the UK for the construction of a 200 MW gas-cooled graphite-moderated natural uranium nuclear power station at Latina, 40 miles south of Rome and for completion in 1962. It will be operated by the subsidiary company SIMEA (Società Italiana Meridionale Energia Atomica). AGIP Nucleare has an agreement with the NPPC on the supply of information on the design and construction of reactors: it is also considering the installation of a pressurized water power reactor in north Italy. The second Italian company to award a contract is SENN (Società Elettronucleare Nazionale) which has entered into an agreement with International General Electric Co for the provision of a 150 MW boiling water reactor station: this will be partly financed by the International Bank. SELNI (Società Elettronucleare Italiana), set up by a group of six companies, has issued a letter of intent to Westinghouse for a 134 MW PWR. Lastly SORIN (Società Ricerche Impianti Nucleari), founded by the Fiat and Montecatini groups is considering the provision of two 150 MW stations.

Valuable experience

Italy will therefore acquire in the next few years valuable experience of the three reactor systems which have reached the stage of commercial application. This experience will provide an important foundation for the nuclear power programme. This has yet to be finally decided, though various forecasts have been made. One proposal is for the completion of 800 MW by 1965. The actual size of the programme will be very dependent on nuclear cost trends—nuclear generation in Italy is very sensitive to capital costs because of capital charges of about 14%. Average hydro and thermal electricity generating costs are about 10 lire (1·4d) a kWh but nuclear power will be expected to be competitive with modern plant built in about 1962 onwards with costs probably in the region of 7·8 lire (1·0–1·1) a kWh. On the other hand a growing base load and interconnexion is to nuclear power's advantage.

Czechoslovakia

Swimming pool reactor near Prague is similar to Moscow's 2000 kW ITR and was supplied to the Czech Institute of Nuclear Physics by the USSR. The Institute also has a cyclotron, a Van de Graaff generator and several radiochemical laboratories

Spain

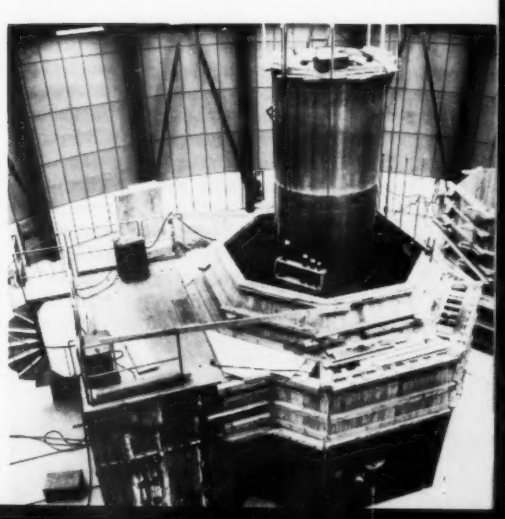
First reactor—a 3 MW pool by General Electric—was inaugurated recently at the Nuclear Energy Board's Moncloa laboratories. Inverted conical structure to the right is a water storage tank.

Denmark

One of three research reactors at Risö is the DR-2, a 5 MWt tank type being supplied by Foster Wheeler of America. DR-1 is a low power swimming pool by Atomics International and DR-3 will be a British PLUTO-type by Head Wrightson

Norway

Fuel elements for the Halden boiling heavy water reactor, now building at the Institutt for Atomenergi, are being supplied by the UK. This is a joint project of the Institute and the European Nuclear Energy Agency



The Netherlands

A memorandum presented by the Minister of Economic Affairs to the Netherlands Parliament last July showed that a heavily increasing dependence on imported energy supplies was an unavoidable result of the continued expansion of industry. Whereas in 1955, home supplies of coal, oil and natural gas provided rather more than half the total energy requirements, they were estimated to be able to supply only 45% of the total by 1965 and 33% in 1975, even with the maximum possible output of indigenous fuels. During these two decades, electricity output was expected to rise by $3\frac{1}{2}$ times, ie at an annual increase of $6\frac{1}{2}$%.

Having compared the costs of electricity generation by conventional and nuclear means, the memorandum concluded that nuclear power could play a major part in meeting future electricity demand and bring about important savings in imported fuels. Cost estimates showed that a nuclear power station with a capital cost (8% p.a.) of 1800 guilders (£170) a kW and with generating costs of 4·4 cts (1·1d) a kWh would just be competitive with thermal stations on base load and the expected downward trend in costs of nuclear power would strengthen its competitive advantage. The memorandum therefore proposed a nuclear power programme to be started in the near future to provide 400 MW of generating capacity by 1965, 1200 MW by 1970 and 3000 MW by 1975. A programme of this order of magnitude would enable energy imports to be restricted to the present proportion at about 50%.

The research and development effort in the Netherlands is carried out by various organizations. Coordination is arranged through the Netherlands Reactor Centre (RCN) set up by the Government in 1955.

Tenders called for

A point has now been reached in the provision of nuclear power where a committee has been set up by the Association of Electric Supply Companies to investigate the three present commercial nuclear power station types (Calder-type, PWR and BWR) and to select sites. It has called for tenders from British, United States and French firms. Like most other industrial countries, Holland will be concerned that a maximum amount of construction and supply work will be sub-contracted to firms in the Netherlands. The first station is expected to be constructed at Geertruidenberg, 40 miles from Rotterdam.

Norway

Consumption of electricity per head in Norway at some 7500 kWh a year is much higher than in any other country in the world: generating costs at about 2 mills per kWh are about the lowest in the world. Total electricity output, which is almost all hydro, was $25{\cdot}8 \times 10^9$ kWh in 1957. Load factor is high, mainly because of bulk industrial consumption. Hydro is, however, Norway's almost sole source of indigenous energy.

The desire for greater flexibility in energy supplies, especially for process steam and ship propulsion, were important economic considerations leading to the formation of the *Institutt for Atomenergi* in 1948. This was followed by the setting up of the joint Norwegian-Netherlands (JENER) research establishment at Kjeller, Oslo, in 1951. Its facilities include a 0·5 MW research reactor, JEEP, which went into operation in 1951 and a number of laboratories. A major undertaking by Norway was the design and construction of a 10–20 MW experimental heavy-water-moderated natural-uranium boiling-water reactor at Halden. The fuel has been supplied by the UK and the reactor is due to go into operation in 1959.

NORATOM was set up in 1957 by a number of companies interested in the industrial exploitation of nuclear energy.

Cheap hydro-electric power offers economic sites to high electricity-consuming ancillary nuclear energy plant. The Norsk-Hydro heavy-water production plant at Rjukan was in fact established as long ago as 1934.

Portugal

Only 15% of estimated hydro-electric resources of 15,000 million kWh per annum are tapped; new schemes cost only 0·48d/u.s.o. Hydro capacity is usually ample, so thermal stations are often idle. Forecast demands for 1964 and 1975 are 4·5 and 12·0 thousand million kWh respectively.

The Portuguese authorities believe that nuclear power is unlikely to be economic before 1975, although pumped storage or stations economic for peak-load operation might be atractive earlier.

The *Junta de Energia Nuclear* is accordingly watching nuclear technology development. Its Research Centre awaits a 1 MW reactor; a pilot installation for extraction of domestic uranium is also projected.

Portugal's policy of wait and see is undoubtedly correct.

Spain

The *Junta de Energéa Nuclear* was set up in 1956 to carry out and coordinate nuclear research. It is now building a research centre at Moncloa near Madrid with facilities to include a 3 MW pool-type reactor now critical and supplied by the United States.

The promotion and coordination of the development of commercial nuclear power is the responsibility of the *Instituto Nacional de Industria* through its special agency, the *Dirección General de Energia Nuclear*. Three groups of private industrial firms including power producers actively considering the construction of nuclear power stations have so far emerged. They are the *Centrales Nucleares del Norte* (*Nuclenor*) which is considering the construction of a 200–250 MW station near the industrial centre of Bilbao by 1965. *Tecnatom SA* of Madrid is interested in the possibility of a 132 MW station at Cadiz and has made an approach to at least one UK firm. Thirdly, *Centrales Nucleares SA* (*CENUSA*) is considering a plant of about 200 MW output near Madrid to operate in 1966.

In choosing, there will doubtless be an understandable preference for natural uranium systems because of a desire to fuel reactors with uranium which has been reported in various occurrences in Spain—a uranium treatment plant is now in operation at Anducar. The first nuclear power stations are likely to be provided by overseas firms but severe shortage of foreign currency may be expected to result in as much construction work as possible being undertaken by Spanish contractors. The povisional nuclear power programme is for the completion of 1000 MW of capacity by 1972 and 2200 MW by 1977.

Sweden

Sweden is faced with a serious long-term energy problem. Her only indigenous conventional source of energy is hydro-power, which now provides more than 90% of her total electricity supply. Consumption is rising at about 7% per annum but hydro reserves are expected to meet future demand for only the next 15 to 20 years. Moreover, much of the hydro reserves are situated a long way from main load centres and necessitate long transmission lines. Already, two-thirds of Sweden's total energy requirements have to be imported, mainly as oil. As much as half these imports are used for industrial and domestic space heating.

The desire for a minimum dependence on imported fuel supplies was an important reason for the early decision to embark on a nuclear energy project. The existence in Sweden of extensive low-grade uranium deposits estimated capable of providing at least 150,000 tons of uranium, well developed scientific research facilities and a progressive heavy electrical industry were also important factors.

The *Atomkommitten* was thus set up by the Government in 1945 to provide financial support for research. Two years later *A.B. Atomenergi* was established as a company owned jointly by the Government and private industry to carry out research and to design and construct prototypes of reactors for Swedish nuclear power programme, either with its own resources alone or with participation of private industry. ASEA, the heavy electrical plant manufacturing group, are actively concerned with the development programme.

The State Power Board, which supplies some 40% of the Swedish electricity supply, is planning the installation of a power reactor in the 100 MW range and one or more in the higher power range during the 1960's. The Board has the advantage of operating at lower capital charges (8–9%) than private power producers. The bulk of the remainder of the present electricity supply is provided by private power companies. Early last year *Atomkraftkonsortiet* was set up by private power producers and industrial firms and has announced its intention to have a major power reactor in operation by 1965.

The choice of natural uranium systems for development for nuclear power production was doubtless influenced by the wish for independence of foreign enriched fuel supplies. The first prototype power reactor, R3/Adam, is thus heavy water moderated and cooled and will provide 15 MW of electricity and also 70 MW of heat for 12,000 dwellings at the new Stockholm suburb of Farsta. This will be followed by R4 (Eve), a 100 MW power reactor to be built for the State Power Board in collaboration with A.B. Atomenergi, ASEA, and the Bofors group.

Ancillary plant includes a small uranium purification plant in operation at Kvarntorp and a larger plant with an output of 120 tons per annum for completion in 1965 and a heavy water 20 t.p.a. pilot plant to be built by ASEA.

The Swedish nuclear energy project is thus well established. The research effort on power development is being wisely concentrated on a very small number of systems. A reduction in prototypes, mainly because of greatly increased cost estimates, has also recently been effected by the combination in R3/Adam, of the formerly proposed district heating reactor at Vasteras, and the reactor at Farsta. Again, plans for developing a number of minor heat producing reactors have been shelved for the time being. This concentration of effort and resources should lead to the successful provision of nuclear power in Sweden by the time it will be seriously required.

Switzerland

Switzerland uses imported fuel for three-quarters of her annual energy consumption of 60,000 million kWh (equivalent). For electricity, however, she can rely on water-power:

INSTALLED CAPACITY	Run-of-river	Reservoir-fed	Thermal
1956/7 MWe (actual)	1850	1900	200
1963/4 MWe (forecast)	2060	5100	? 400

The river stations supply base-load requirements, shedding summer surplus to reservoirs (and industrial bulk consumers); peak winter loads are met by the storage stations. The scope for further river stations is limited; demand, growing at 5% annually, will be met by new storage stations which can produce 12-mill power about 5 centimes/kWh. It is expected that the base/peak load rates will steadily improve. Western Switzerland already imports base-load supplies.

Within the next 15–20 years, hydro reserves will also run out, and alternative sources will be needed: estimates range up to about 1500 MW, perhaps a third of which might be nuclear.

The Government has allotted Sw.frs. 160 m (£13 m) for a 5-year research programme. Reactor AG operates the Government-subsidized centre at Würenlingen.

Although the first power reactor experiment will probably be a 10/20 MW BWR, the Calder Hall system which does not require enriched fuel, and should be economic at the 4% interest rate which prevails, is under study. At UK prices, 6 mills power should be possible but Swiss estimates for an underground version range up to 30 mills.

There is no immediate pressure for a new power source, and the Swiss can afford to wait for proof elsewhere of the most efficient reactor system.

Czechoslovakia

Czechoslovakia is a small, highly industrialized country with limited energy resources. Electrical generating capacity is increasing relatively slowly compared with the rate of increase in the lesser developed eastern European countries—7½% p.a. The bulk of the supply comes from thermal stations—85% of the total 4800 MW.

There are, however, ample supplies of uranium; the Joachimsthal mines in Bohemia are the largest producers in Europe.

The first station is planned to go into operation in 1963. It has a capacity of 150 MWe and is being built with substantial Soviet help. It is interesting that the system chosen, natural uranium, heavy water, gas-cooled, at one stage figured in the USSR programme but has since apparently been dropped. It will be at Bohunice near Bratislava.

Precise details of the longer term plan are not known, but apparently all new capacity after 1965 will be nuclear and by 1970 one-third of the electric power generated will be nuclear in origin. This implies a nuclear capacity in that year of about 3000 MW.

Poland

Poland is a country exceptionally well endowed with coal and lignite and known reserves are enough to cover needs for another century, even taking account of increased consumption. At the moment Poland exports coal and expects to be able to continue to do so at least until about 1970–75. There is little or no hydro potential.

A rapid increase in electrical generating capacity is planned:

ELECTRICAL GENERATING CAPACITY (MW)

1955	1960	1965	1970	1975
4178	6600	9800	14,300	21,000

It is considered that, in view of this very rapid growth, it would be unwise to rely entirely on the ability of the Polish coal and lignite industries to cope with this increased demand. It is thought that the twenty year breathing space her coal reserves allow should be used in Poland to establish a firm base for bringing nuclear power into the economy in the late 1970s. By this time a great deal of the speculative element will have been removed and it will be possible to make a rational decision as to whether to substitute nuclear for thermal power or not.

In order to provide the evidence for

making this choice, 800 MW of nuclear capacity is planned in Poland between 1965 and 1970, with possibly a further 1000 MW by 1975. This would bring nuclear capacity up to 10% of the total by 1975.

As Poland has uranium deposits of her own and cannot afford to build a diffusion plant, natural uranium systems will be used. The first generation will be graphite-moderated and gas-cooled. The idea is to use the plutonium these produce to fuel fast breeder reactors in the late 1970s, much along the UK lines.

Nuclear energy research is centred on the Institute for Nuclear Research in Warsaw. There is a further institute, concerned mainly with theoretical nuclear physics, at Cracow. A 2 MW Russian designed reactor is being installed at Swierk, 15 km from Warsaw.

Rumania

About 80% of total energy consumption now comes from oil and natural gas; about 17% of this is used to generate electricity. Consumption in 1960 is planned to be 7500×10^6 kWh and this will require a total capacity of about 1300 MW. So far, little use of hydro and lignite reserves has been made, but these are considerable, especially the Danube hydro reserves. The intention is to try to make more use of oil and natural gas as raw materials for, e.g. artificial fibres and plastics, and less use of it as fuel.

In these circumstances it is unlikely that nuclear power will be of economic interest much before 1970–75. By 1975, it is thought, there might well be about 500 MW of nuclear generating capacity.

Yugoslavia

Yugoslavia is a country whose industrial development dates only from after the war. It is rich in mineral resources and its generally mountainous nature suits it to hydropower development. The Iron Gate site on the Danube is particularly well suited for a large hydro-electric station, though its use is at present made difficult by the political relationship with Rumania. Uranium deposits have been found and prospecting is continuing.

Work on nuclear energy is controlled by the Federal Nuclear Energy Commission which co-ordinates the work of the various Institutes. The most important of these is the Boris Kidric Institute of Nuclear Sciences at Belgrade. It is here that the Yugoslavs themselves constructed the zero-energy heavy water natural uranium assembly which recently killed one operator and gave five others doses of several hundred roentgens. In addition, the Yugoslavs will shortly have at their disposal a 7–10 MW heavy water research reactor built in the USSR.

Other E. European countries

Eastern Germany is to have a 70–100 MW nuclear power station by 1961. It will use a PWR and will be based on the USSR Voronezh-Leningrad station. It will be sited inland on a lake. Eastern Germany also has a 1–2 MW water-moderated-and-cooled Soviet research reactor. It was completed in 1957.

Bulgaria and Hungary are also to receive similar research reactors; they will be working by 1959 or 1960.

THE FAR EAST

Japan

The new Long Term Economic Plan for Japan envisages a continuance of the present rapid economic expansion throughout the next two decades, so that by 1975 the gross national product will be more than two-and-a-half times as large as in 1956. Estimated fuel requirements for the period expand almost as rapidly.

Although Japan's scanty domestic sources of primary fuels and hydro power will be exploited with characteristic vigour, her dependence upon imported fuel is bound to increase rapidly — from about a quarter of primary fuel supplies in 1956 to perhaps almost a half by 1975.

For Japan, atomic energy is both an import-saver and a tool for developing the highly industrialised economy. It is planned to install an output capacity of 7,000 MWe over the period 1962/75; half of the generating stations built in the period will be nuclear.

The programme provides for domestic manufacture from imported concentrates of all fuel except initial charges for the first and second 150 MW reactors. In early stations, natural-uranium gas-cooled graphite-moderated reactors will be installed. If the whole 7,000 MW were supplied by these reactors, developed for plutonium re-cycling, higher operating temperatures and lower capital costs in line with recent published forecasts, it is claimed that by 1969 the annual import content of the atomic energy programme would be less than that for an equivalent capacity of fossil-fuelled stations.

Forecasts of import saving are notoriously uncertain; in this case, much depends on the rate at which Japanese industry can take over the manufacture of components. The programme assumes that, even in the first station, 60% of the cost will be in local currency and that by 1968 only 7% of construction cost will be spent in foreign currencies. This sanguine assumption is balanced by a prediction that the thermal efficiency of fossil fuel stations will increase by 50%, reaching 39% in 1975.

The programme is not wedded to the Calder Hall type of reactor, although its appeal has been strengthened by the discovery that it can be protected readily against earth tremors. Water-cooled reactors need enriched fuel, which is expensive in foreign currency, or would require a large Japanse effort on diffusion-plant design. Research facilities include three water-moderated reactors built or building, which will provide useful experience, although extrapolation to predictions about the performance of water-moderated power-producing reactors is fraught with difficulty.

Production of heavy water, as well as graphite, has begun on a small scale, and a 10 MW isotope-producing reactor is to be completed next year.

Towards the end of the period it is hoped that breeder reactors may be introduced, to use accumulated plutonium for their initial charges and only a modest make-up of natural uranium. A complete programme has been devised.

Although perhaps optimistic in some respects (e.g. the date for Japanese manufacture of fuel elements), the programme has been conceived as an economic necessity, is backed by adequate research and development facilities, and is on a scale commensurate with Japan's proven organisational abilities.

India

The principal interest in thinking about the Indian nuclear power programme lies in its being related to a low income country in course of rapid industrialization. The rate of growth of generating capacity is extremely rapid; it doubled in the First Five-Year Plan, is planned to double again during the current Plan and might well continue to do so for at least a further five-year period.

PLANNED INCREASES IN GENERATING CAPACITY ($MW \times 10^3$)

1956	1961	1966	1971	1976
3·5	7	12–15	18–30	25–53

Reserves of hydro are between 35 and 40 thousand MW. Known coal reserves at 40,000 million tons are not large by world standards and they might well soon start getting difficult to mine as production is raised. In the long term, then, if Indian industrialization is not to be checked by a power shortage, use will have to be made of nuclear power. The problem is when a start ought to be made.

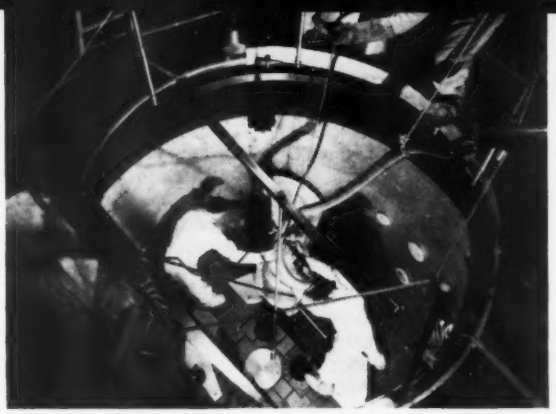
The position is complicated by transport problems. India's coalfields are in the East—most are within three hundred miles of Calcutta—but there is a substantial energy demand in the West, round Bombay. The correct solution to this problem in the present, relatively early, stage in India's development, would appear to be to build railways, which have the advantage of contributing to the overall development of the economy, rather than transmission lines, which have the disadvantage, as a transport system, of only being capable of transporting one commodity.

Dr Bhabha's Geneva paper (P/1624) gave an admirable and clear presentation of the position facing low-income countries embarking on a long period of economic expansion. He showed that in such countries even with transporting the coal 700 miles, total investment in thermal electricity fell short of total investment per kW of nuclear power in distant areas—£120 per kW for thermal as opposed to £190 per kW for nuclear. Even taking the lowest conceivable practical rate of interest—and surely one inapplicable to a low income country—of 4½% the cost of nuclear power still came out above thermal power.

Nevertheless, India is certainly quite right in going ahead with a nuclear power programme. It will ultimately have to have one; the problem is one of timing. It may be questioned whether the Indian programme of 250–1,000 MW by 1966 is not premature. Certainly the upper end of the range would seem to be. The position is complicated though, by the wish to use Indian thorium. This can only be burnt when a stock of U-235 or plutonium has been built up, and this can only be done by building a costly diffusion plant or by operating plutonium-producing reactors.

Pakistan

Pakistan is not at all well off for fuel supplies; Eastern Pakistan particularly so. In the West the two most promising sources of energy are the rather remote hydro resources in the foothills—about 9000 MW—and the

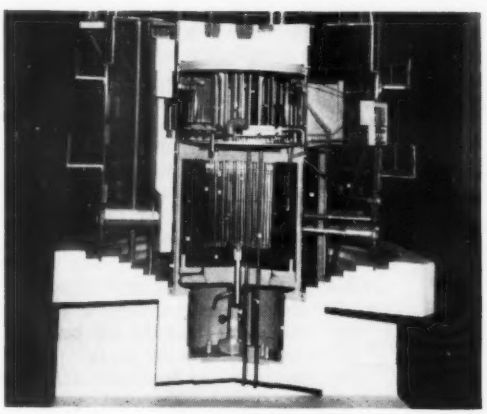


Australia

Part of the extensive research facilities at Lucas Heights is the high flux reactor HIFAR, shown here under construction

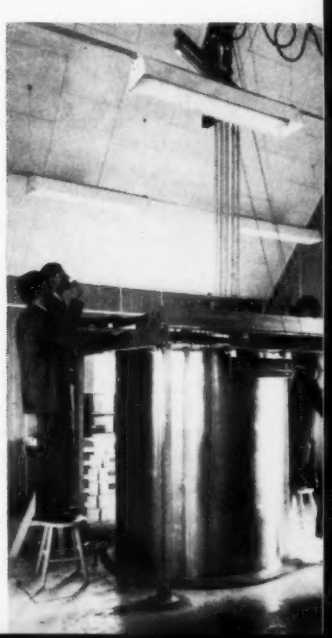
India

In addition to two research reactors at Trombay—a pool in operation and the NRX-type Canada-India reactor under construction—is the thorium plant shown here



Switzerland

This medium flux, heavy-water moderated reactor was designed and is being built by Reactor Ltd at Würenlingen. The company also has a pool-type reactor, Saphir, in operation since 1955



Finland

First steps are being taken by Ydin—a group of companies—with this subcritical assembly. Natural uranium came from the UK, graphite from the USA, and the Po-Be neutron source from USSR

Sui natural gas field, about 200 miles north of Karachi. Coal production in W. Pakistan (500,000 tons) covers only one quarter of demand and oil production (1·8 million barrels) one-fifth. Energy sources in E. Pakistan are negligible; electrical generating plant is almost entirely diesel running on imported fuel. The cost of power is about 1¾d–2d per kWh. In these circumstances, it is thought that a small nuclear power station will prove competitive—even with high interest rates—since the cost of the imported fuel is so high.

Chinese Peoples Republic

China has the third largest known reserves of coal of any country in the world; it also has large unexploited reserves of hydro power. In these circumstances, despite the extremely rapid increase in industrial activity, China's interest in nuclear power must remain largely theoretical for many years to come.

They have, however, already embarked on a research and radio-isotope production programme; this latter is of especial importance to a primarily agricultural country. The USSR has built them a 10 MW heavy-water moderated research reactor which went critical in September 1958.

China (Taiwan)

With a population of 10 million increasing at 3½% p.a., Taiwan will have, in the long run to industrialize to maintain, let alone increase, her standard of living. Installed capacity which fell from 320 MW to 62 MW immediately after the war, has been built up to 540 MW—75% hydro.

By the end of 1961, installed capacity will have reached 1000 MW. Demand increased at the rate of 15% p.a. from 1923 to 1943, and again from 1948 to the present. This rate of increase is expected to continue at least until 1962; it might then drop to 8·5% p.a. Hydro reserves amount to about 4600 MW—most of it difficult to get. Coal reserves are only 90 million tons deliverable; they might well only last 20 years.

It is estimated that, by the end of 1968, it will either be necessary to import coal or oil, or nuclear power. Depending on relative costs, which will have been clarified by then, there might well be a market for a nuclear power station of 160 MW.

Other Far East Countries

Burma has decided that nuclear power cannot yet be introduced economically into their generating system. Hydro reserves are very large; 21 sites surveyed yielded a potential capacity of 2000 to 3000 MW; present total capacity is 150 MW.

It might well be, though, that nuclear power will become more attractive in the future than it is today; hydro power is inconveniently situated for the rapidly increasing Rangoon area load. To prepare for this eventuality there has been set up the Union of Burma Atomic Energy Centre, with numerous responsibilities, including training specialists and making periodical nuclear power economic assessments.

The Philippines might provide a site for a nuclear power station in the late 1960's or 1970's. A US company investigated the possibility of installing a 60 MWe PWR there in 1956 but decided that the proposal was premature.

Viet Nam proposes to establish a research centre at Dalat, about 180 miles from Saigon, and plans to buy a small US research reactor.

AUSTRALASIA

Australia

Energy requirements of Australia are generally considered on a State basis rather than on a Commonwealth (Australian) basis, partly because of the vast scale of the territory in relation to the size of population and also as a result of the Federal nature of the constitution. New South Wales coal is the main indigenous source of energy. Coal is also mined in most other States but the scale is small and is often insufficient for State needs. Total Australian coal output is now running at about 20 million tons a year. There also is considerable hydro development in the south-east of the country, but there are no economic resources of oil or natural gas in any State. Total electricity generating capacity in Australia is some 3400 MW at the present time.

The more immediate prospects for nuclear power would appear to be:—

(a) small-sized stations for remote areas, e.g. mining areas
(b) medium-sized base-load stations for cities where coal is relatively expensive and
(c) large base-load plant to supplement coal-fired stations in the industrial areas of the south-east.

Generating cost requirements of nuclear power would be in the range 20 mills per kWh (for (a) above) to 5 mills per kWh (for (c) above).

The Australian Atomic Energy Commission was set up in 1952. Its chief research establishment is nearing completion at Lucas Heights, near Sydney and its main facility, the 10 MW materials testing reactor HIFAR supplied by Head Wrightson Ltd of Britain, was completed in 1958.

Long-term research effort is being concentrated on high temperature reactor systems.

New Zealand

A large-scale development programme is now being undertaken in New Zealand of indigenous power resources, especially the extensive hydro-electric capacity of South Island. The latter is not in general ideally situated as only one-third of the country's total population of 2 million lives in South Island while the remaining two-thirds live in North Island. Even so, with transmission lines some hundreds of miles in length and a submarine cable to be laid under the 25-mile Cook Strait, power is estimated capable of delivery at only 0·5d per kWh at the terminal of the cable near Wellington in North Island. Capital costs of the hydro-electric plants in the scheme are estimated to be between £75 and £100 a kW—in size, they range up to 480 MW. New Zealand also has important sources of geothermal steam: the plant at Wairakei will produce power at less than 0·4d per kWh.

Last year, the Combined Committee on New Zealand Electric Power Supply was set up to examine future power supplies and its report suggested the large-scale development of existing indigenous resources, especially hydro power would be sufficient to meet demand until at least 1970. A decision on the introduction of nuclear power was not required at the present time.

The research effort currently undertaken is small but is supported by a continuing interest on overseas developments.

MIDDLE EAST AND AFRICA

Union of South Africa

Coal produced in the Transvaal can be delivered at nearby electricity generating generations of the Electricity Supply Commission at 7s 6d to 11s a ton: on the other hand for places distant from the main coal producing areas, transport costs constitute a much larger factor in the delivered price of coal than mining costs, e.g. the price of coal at Cape Town and Port Elizabeth is about 45s a ton. Total production in the Union is increasing and is now running at about 35 million tons. There is virtually no

indigenous oil and hydro-electric capacity is negligible.

On the other hand, South Africa is one of the world's leading uranium producers. Output of uranium oxide, U_3O_8, was expected to reach about 6000 tons in 1958 (equivalent to 50 million tons of coal if irradiated to 3000 MWD/t in nuclear power stations). Uranium is now South Africa's second most important export. Reserves of uranium are estimated at 370,000 tons of U_3O_8.

Because of plentiful cheap coal, there would appear to be no general need for nuclear power for some years. The first requirement is likely to be in the Cape Town area, and there would appear to be possibilities for small nuclear power plants in isolated areas, e.g. at the diamond mines at Oranjemund in South West Africa. The Forsyth Commission is examining the future energy situation in South Africa, with particular reference to the role of nuclear power.

The South Africa Atomic Energy Board (1949, reconstituted 1958) to exercise general control of nuclear energy developments but with a particular responsibility for uranium mining, refining and prospecting. Nuclear research is still on a small scale but the Universities of Cape Town and Stellenbosch are collaborating in establishing a central institute for research to be equipped with a research reactor.

Israel

Electricity generating capacity in this small country has increased rapidly in the last decade and now totals about 300 MW. It is expected to increase to 600 MW in 1965 and to 900 MW in 1975. After 1965, when the cost of nuclear power is expected to have fallen appreciably, it may well be introduced in Israel on an increasing scale and bring about savings of foreign exchange on oil imports, which would outweigh the necessary overseas expenditure on nuclear plant.

The Israel Atomic Energy Commission was set up in 1952 and is linked with various research centres, e.g. the Weizmann Institute.

Other Middle East Countries

The economics of nuclear power are unattractive to the oil-producing countries. Jordan's requirement (<50 MW by 1965) are small and uncertain. The United Arab Republic however, is to receive a 2 MW research reactor from the USSR and its Atomic Energy Commission is active both in Egypt and Syria where hydro-power resources (even including the High Dam) will need supplementing in the mid-1960s. There is already a base-load demand for power 0·6d/kWh, and nuclear power may, if technical assistance is provided, be installed on a small scale—say 200–300 MW by 1970.

LATIN AMERICA

Argentina

The Atomic Energy Commission have estimated that the installed capacity of public power plants will rise from 1600 MW (100 hydro) in 1955 to 3600 MW (900) in 1965 and 10,000 MW in 1980. Local coal, oil and hydro resources should continue to provide for all but the distant central and eastern (Buenos Aires) regions, which might by 1980 support about 2000 MW of nuclear power.

Present plans are to use local uranium (a pilot extraction plant is already working) for a natural uranium 150 MW station near Buenos Aires. Prospects for further installations are promising.

Brazil

Present official estimates are that accessible hydro power resources (about 17,000 MW) will be exhausted by 1975. Generating capacity should then be about 22,000 MW.

Recent forecasts are that about 500 MW by 1965, and about 3000 MW by 1975 might be nuclear. The short-term plans of the National Commission for Nuclear Energy are for at least one 100–150 MW station near Sao Paulo, several 100 MW stations in centres not on the grid, and for very small stations if these can compete with small diesels (at around 20 mills/kWh). There is hope for Thorium/U-233 breeders fuelled by Brazilian uranium and thorium.

If the transmission system and the foreign exchange position are strengthened, a sizeable programme for nuclear power should be possible.

Chile

As in Argentina, principal hydro resources are remote from load centres —in this case Santiago/Valparaiso and the northern mining areas. Demand will continue to grow rapidly. Present installed capacity is about 1000 MW (520 hydro). Totals forecast are 1650 in 1964 and 2500 in 1972.

Local coal is expensive, but imported oil can be distributed fairly easily. In the mining areas, small nuclear stations (less than 20 MW) could find a market at about 25 mills/kWh. A grid system covering the northern and central areas is being completed, and during the next ten years a base-load 150 MW Calder-type station could be economic. The national electricity company ENDESA, which owns a third of total capacity, is studying nuclear energy developments.

Cuba

Locally refined Venezuelan oil provides most of the fuel for electricity generation and even large industrial consumers have to pay 25–30 mills/kWh. Load factors remain fairly high.

CAPACITY OF PUBLIC UTILITIES

	INSTALLED CAPACITY MW	CONSUMPTION MILLION kwh
1952	183	775
1953	191	852
1954	227	928
1955	267	1020
1956	268	1143
1957	303	1282

Major industries (eg sugar) remote from load centres possess another 400 MW.

Cuba has decided, through its National Bank for Social and Economic Development, to buy a 20·5 MWe BWR with oil superheating from the Anglo-US corsortium AMF-Mitchell. Just over 20% of the heat generated will come from the oil superheating.

The plant will be built at Santa Lucia, in the copper mining province of Pinar del Rio. Although capital costs will be slightly higher than for an alternative conventional plant, the high load factor—80%— should make electricity from the nuclear plant slightly cheaper. The station is planned to be finished by 1961.

Uruguay

Uruguay has no fossil fuel resources, and limited hydro power storage capacity, so that thermal stations have to make good dry season shortages. The present capacity—about 320 MW, all nationalized—should increase to some 700 MW over 10 years, about half the increment being hydro, and the remainder two 100 MW stages (1963/5) of a 500 MW station. It has been suggested that these stages might be nuclear.

A decision for nuclear power on this scale would require exceptional boldness, but could be justified by Uruguay's pressing needs for a new source of energy.

Other Latin-American Countries

Most of these countries possess resources of hydro-power or oil and grid systems in various stages of completion. Atomic Energy Commissions, some of which conduct or supervise research, have been formed in several countries. In Colombia, Mexico and Peru, preliminary investigations into the economics of small power reactors are known to have been undertaken. The next generation of small US reactors may begin to open these markets in the mid 1960s.

CANADA

Because great distances (and corresponding transmission line losses) separate the major electricity-consuming areas in Canada, country-wide analysis of comparative generating costs for different fuels would be misleading. In British Columbia, Quebec and the Prairie and Maritime provinces, the competitive position of local distributed power generated by hydro-electricity, natural gas and brown Nova Scotian coal is likely to be unassailable for many years. In Ontario, however, where expanding industrial activity is fed by hard coal from the USA, there could be increasing scope for nuclear power.

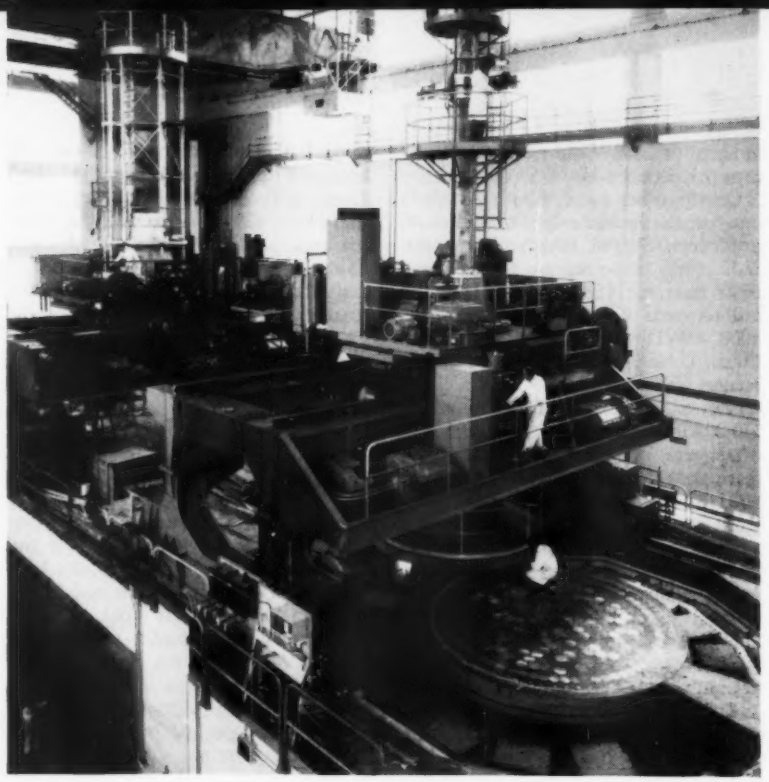
Since the war, technological, transmission line and constructional advances have reduced the real cost of both hydro-electricity (upon which over 90% of industrial bulk consumers rely) and fossil-fuel generated power. Thermal power has cheapened faster, and it has been estimated that by 1965 the two main sources will be competitive:—

	HYDRO (CANADA)	THERMAL (USA)	MILLS/KWH S.O. LARGE POWER CUSTOMERS)
1945	6·6	15·0	
1956	5·0	8·8	at 1955 prices
1965	6/6·5	7/8	at 1955 prices + 50%

Allowing for the pace of technological progress in the reduction of nuclear power costs, it has been assumed that a reactor system producing 6 mills power at today's prices should be fully competitive with conventional power sources by 1965.

Accent on heavy water

Research and development in nuclear power in Canada is conducted by Atomic Energy of Canada Ltd, a Crown (public-controlled) Company at Chalk River, Ontario. This establishment continues a collaboration with the USA and the United Kingdom which began during the war.



Most powerful research reactor in the world, the NRU has been in operation at Chalk River since November 1957. Experience accumulated on Canada's other high flux reactor, NRX—first critical in 1947—was used in the design

The accent of reactor work at Chalk River is heavily upon the development of a heavy-water-moderated, natural-uranium fuelled system with reactors such as ZEEP, NRX, NRU, and the power prototype NPD.

This concentration upon the heavy water/natural uranium approach may be explained in terms of Canada's vast known reserves of uranium ore (estimated to contain up to 250,000 tons uranium), which are exploited by another Crown Company, Eldorado Mining and Refining Ltd. The market for these would be greatly strengthened if an economic reactor system were devised which used natural uranium in a once-through cycle.

The design of such a reactor is being studied by AECL. Heavy water is the obvious choice for moderator, and would enable very large reactors to be run on natural uranium, thereby avoiding the complications of recycling and plutonium extraction. It is hoped that by 1965 a 200 MWe reactor can be built to burn sintered UO_2, zircaloy-clad fuel to 8000 MWD/Te on a once-through cycle. Reactor control would be secured by a gas-balanced system to raise and lower the height of the heavy water moderator. The coolant (heavy water) would be circulated in zircaloy pressure tubes. It is hoped that this design could be expanded for a 1000 MWe reactor by the late 1970s.

Using this system, the installed capacity of nuclear stations in Canada is predicted as follows:—

MWe INSTALLED CAPACITY

	NUCLEAR	TOTAL
1958	—	~18,000
1966	200 — 1000	
1971	600 — 1700	
1976	2000 — 3000	
1981	4000 — 7000	~48,000

the range being determined by the relative attractions of highly efficient thermal stations.

Some uncertainties

Although much irradiation experence with zircaloy has now been gained, a number of question-marks hang over this programme:—

(a) The uncertainties connected with the use of heavy water cooling at high temperatures and pressures.
(b) High costs and fabrication problems with zirconium.
(c) Behaviour of UO_2 cooled in high-temperature water.
(d) Possible advantages of gas-cooling.

There is no reason to doubt that the strenuous efforts now being made to remove these uncertainties will succeed; but whether the resultant system will prove capable of meeting the economic challenge of Pu-breeding reactors or other advanced systems using enriched fuel is an open question. The single-mindedness of the reactor-development programme provides its present strength, but leaves no eggs for other baskets.

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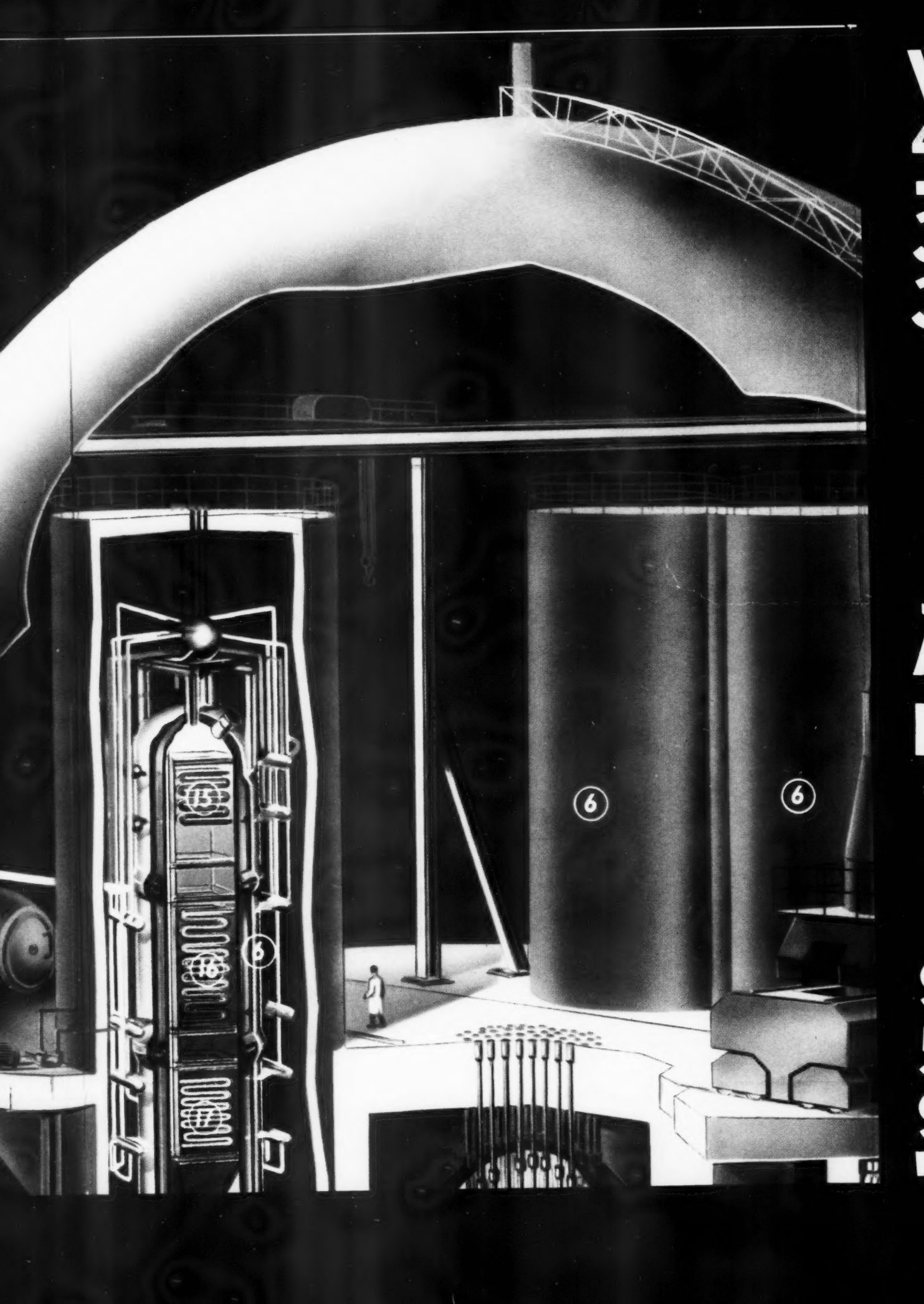
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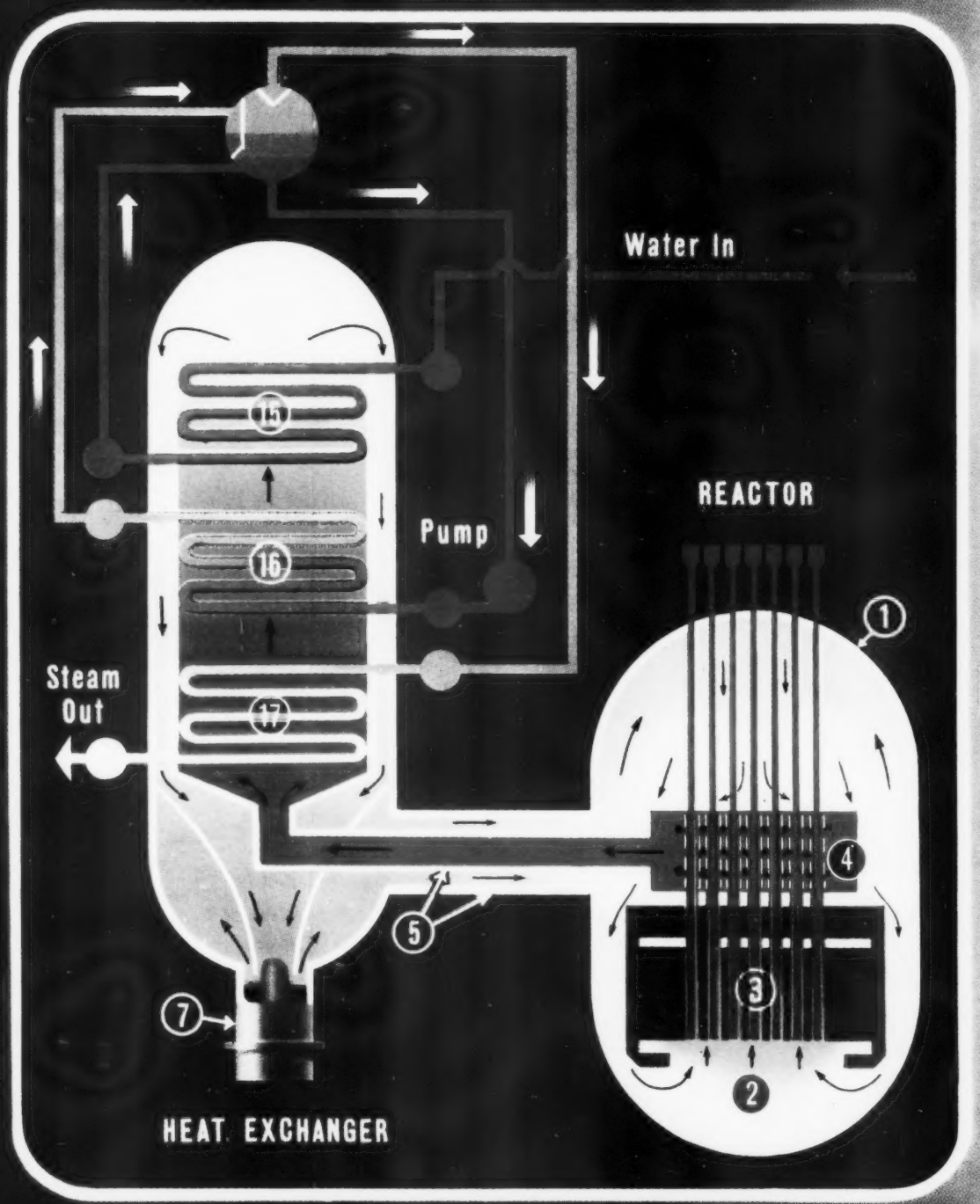

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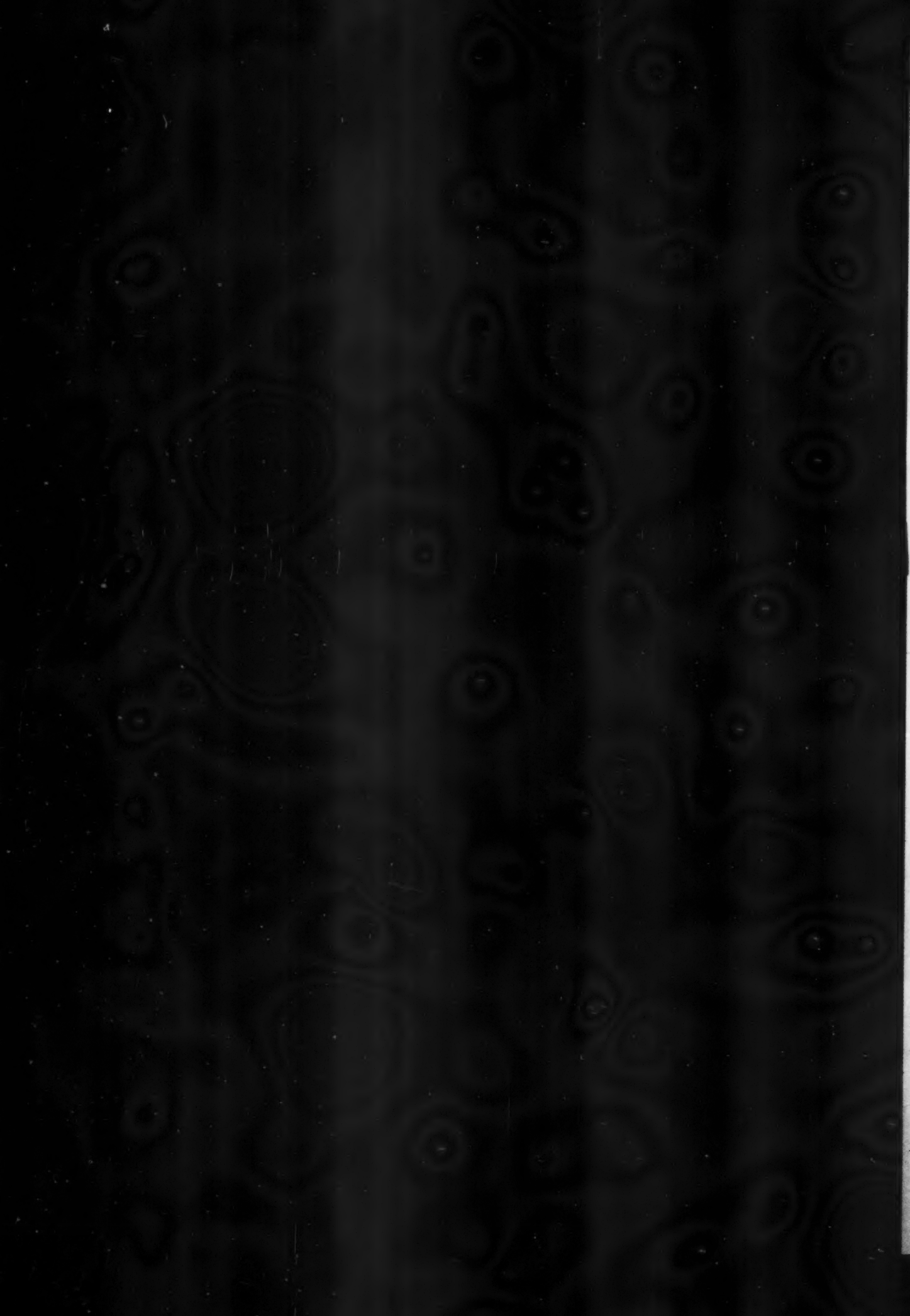


THE ADVANCED GAS-COOLED REACTOR

At its Windscale Works, the United Kingdom Atomic Energy Authority plans to have completed by early 1961 a power reactor experiment known as the Advanced Gas-Cooled Reactor (AGR). The object of this is the development of a new generation of graphite-moderated gas-cooled reactors which will have a much higher performance than the nuclear power stations now under construction in the UK. This will give considerably reduced capital costs and much improved fuel utilization.

Like Calder Hall and the early commercial power stations AGR will be moderated by graphite and cooled by carbon dioxide but here the resemblance ceases. The fuel elements for the first charge will now not be thick bars of natural uranium metal clad in magnesium alloy, but pellets of uranium oxide contained in small bore beryllium tube.

By this means it is expected that the maximum temperature can be raised about 200°C above Calder values and the amount of heat extracted per ton of uranium increased four or five times. But doing this will mean using uranium which has been enriched to contain about 1¾% of the fissionable uranium 235. For future fuel charges even more advanced elements will probably be used.

In the detail design of AGR, many novel features not found in the first round stations will be noticed. Each fuel channel, for example, is connected to its own branch in the pressure vessel head and is fitted with its own instrumentation and flow control. Provision is also made for tubes to be passed right through the core, isolating a channel for loop experiments. Refuelling can be carried out on load by the machine (8). Another advanced feature of the core is the provision of means for replacing the graphite should it ever be required.

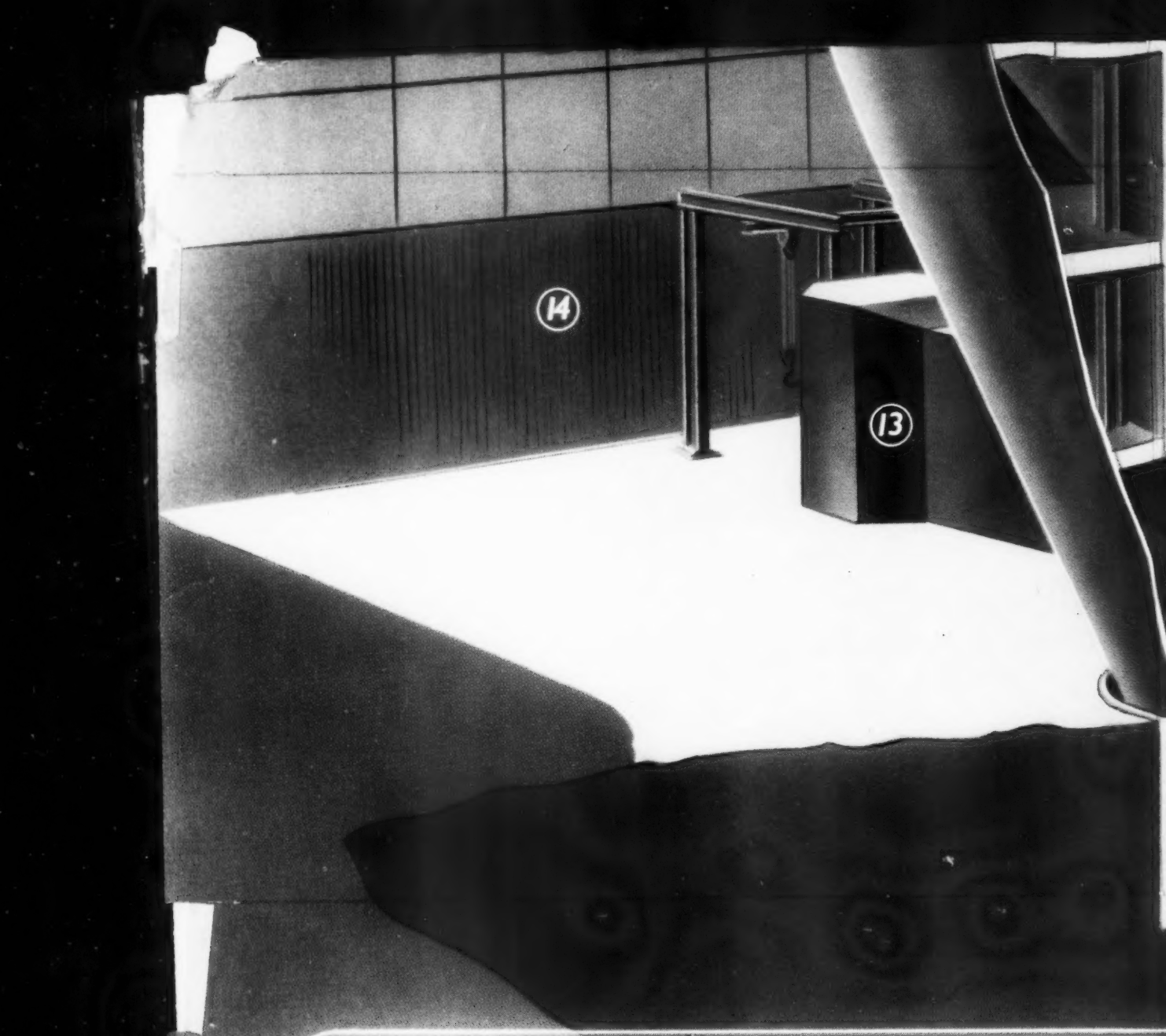
The pressure vessel is of double skin construction which enables the whole outer shell to be kept at the lower gas temperature. The heat exchangers, too, are of double skin construction and are raised high above the core to give a degree of natural circulation in the event of a circulator failure.

Although the AGR will produce 28MW of electrical power it is considered essentially an experimental plant and a modest single-pressure steam cycle has been chosen for simplicity. Commercial AGR's would of course use more advanced steam conditions.

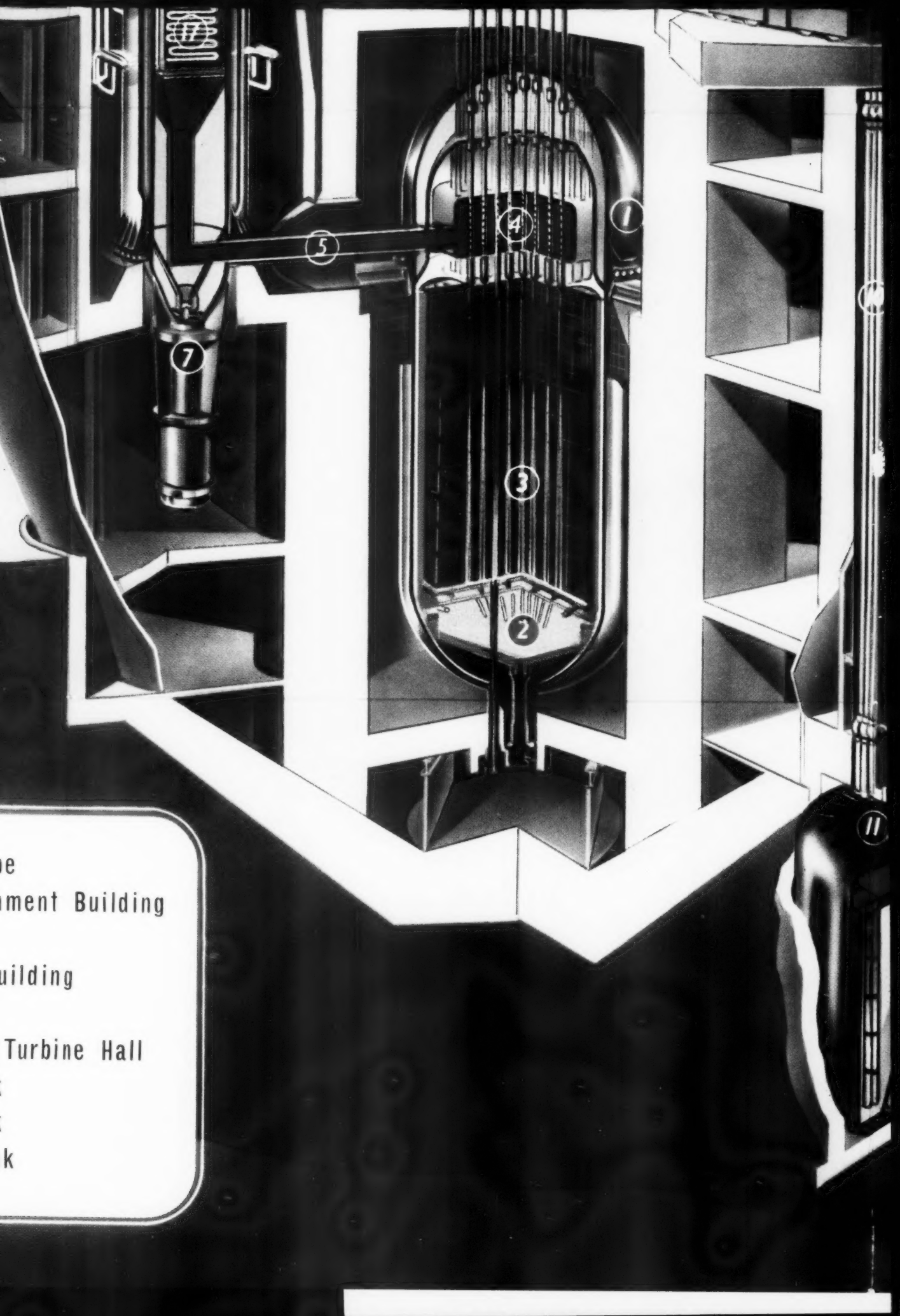
Safety problems are similar to first generation stations in that the fuel elements are designed to contain fission products, thus keeping the coolant circuit clean. But in view of the experimental nature of the reactor it was decided to enclose the reactor and heat exchangers in a containment shell capable of holding the entire gas contents in the circuit.

MAIN PARAMETERS, PERFORMANCE AND DESIGN DATA OF THE AGR

Reactor heat rate	100MW



1 Reactor Vessel
2 Cool Gas Entering Core
3 Fuel Elements In Core
4 Hot Gas Leaving Reactor
5 Ducting
6 Heat Exchangers (4 off)
7 $C.O_2$ Circulator
8 Re-Fuelling Machine
9 Containment Building
10 Fuel Access Tube Through Containment
11 Carousel
12 Fuel Element Building
13 Air Locks
14 Control Room & Turbi
15 Economiser Bank
16 Evaporator Bank
17 Superheater Bank



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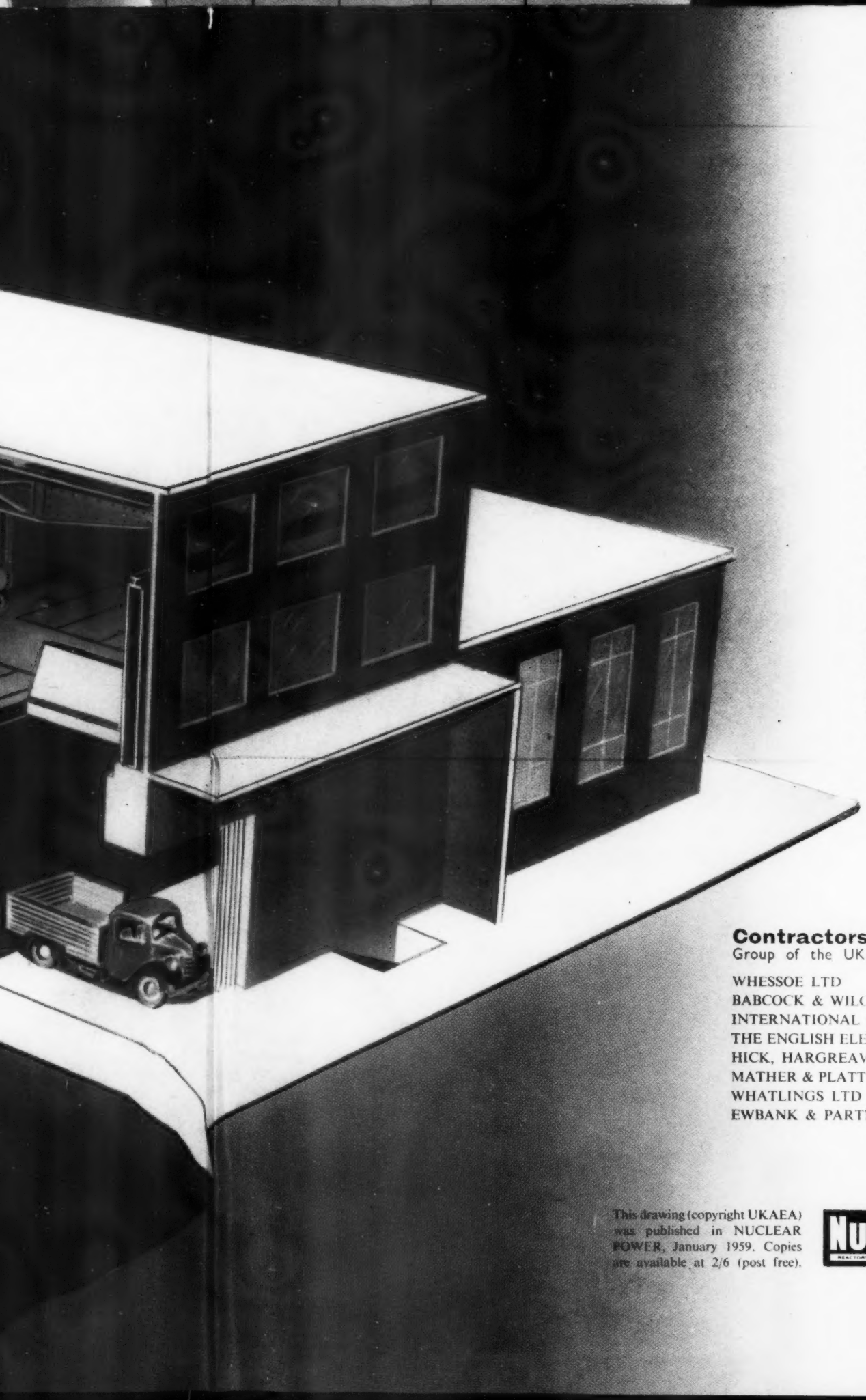

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MATHER & PLATT LTD
WHATLINGS LTD
EWBANK & PARTNERS LT

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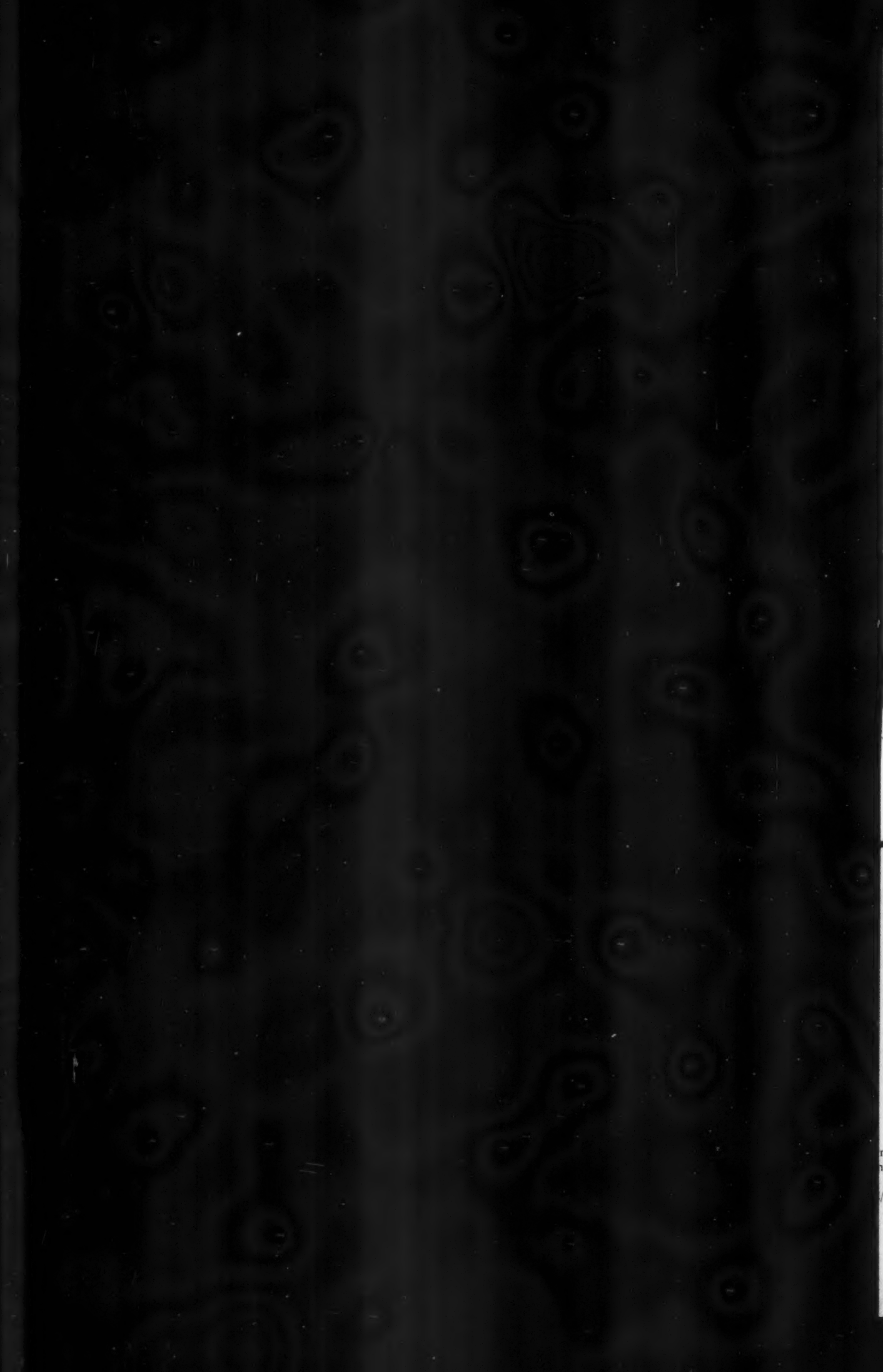

MAIN PARAMETERS, PERFORMANCE AND DESIGN DATA OF THE AGR

Reactor heat rate	100MW
Net electrical output	28MW (E) approx.
Core length (excluding reflector)	14ft
Core diameter (excluding reflector)	15ft
Total number of channels	250
Gas pressure at inlet to reactor	270 psig
Gas temperature at inlet to reactor	250°C rising to 325°C
Bulk gas outlet temperature	500°C rising to 575°C
Normal maximum fuel element can surface temp.	600°C
Total weight of UO_2 fuel in core	14.6 tonnes
Mean reactor rating	7.75 MW/tonne
Peak reactor rating	18.00 MW/tonne
Initial enrichment	1.65 C_o (approx.)
Average thermal flux	1.49×10^{13} n/cm² sec
Peak thermal flux	3.45×10^{13} n/cm² sec
Number of control rods	25
Total reactivity absorbed	14% approx.
Cylindrical pressure vessel, internal dia.	21ft
Cylindrical pressure vessel, overall height	60ft approx.
Weight of moderator, including reflectors	200 tons approx.
No. of external circuits	4
No. of main circulators	4
Power of circulator coupling	1,200 h.p. approx.
Charge and discharge of fuel	On load
Steam cycle	Single pressure
Superheater outlet pressure	620 — 670 psig
Superheater outlet temperature	860°F (460°C)
Turbo-alternator	One
Dump condenser rating	100 MW

Contractors — The Advanced Gas-Cooled Reactor was designed by the Industrial Group of the UKAEA and is being built by a number of contractors. These include :

WHESSOE LTD	reactor pressure vessel
BABCOCK & WILCOX LTD	containment shell
INTERNATIONAL COMBUSTION LTD	heat exchangers
THE ENGLISH ELECTRIC CO LTD	turbo-alternators
HICK, HARGREAVES LTD	dump condenser
MATHER & PLATT LTD	feed water pumps
WHATLINGS LTD	building and civil engineering
EWBANK & PARTNERS LTD	consulting engineers for turbine plant

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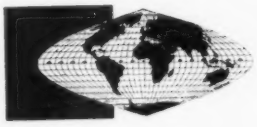
REACTORS



WORLD REPORT JANUARY 1959

For some time there has been a real need for an easy-reference catalogue to the power and research reactors going up all over the world. The information in the following seven pages has been compiled by Nuclear Power staff from papers presented at the Geneva '58 conference and from other reliable published sources.

Listed in chronological order of criticality, reactors have been classified mainly by moderator and are shown as either in operation (O), under construction (C) or definitely planned (P)—design studies and projects have not been included. Research reactors no longer in use and those built for a special purpose have also been omitted.

Power reactors : output is from one reactor unless otherwise stated in brackets ; coolant temperatures are mainly average in the core unless given as exit values.

Research reactors : high power reactors are defined as those over 5000 kWt ; neutron flux figures are in $n/cm^2/sec$ and are for thermal neutrons except in the case of fast reactors.

POWER REACTORS AND PROTOTYPES

	NAME and/or OWNER	STATUS and FIRST LOADING	LOCATION	PRINCIPAL CONTRACTOR	NET OUTPUT MWe	FUEL type (enrichment) form cladding	COOLANT type, pressure (psia) temp (deg C) flow (lb/min)	NOTES
GRAPHITE	APS–1	O '54	Moscow (Obninsk)		5	U alloy (up to 5%), press. tube, S.S.	H_2O, 1420, 190	has operated boiling
	CALDER HALL A & B (UKAEA)	O '56–'58	Sellafield, England	—	140(4)	nat U, rod, Magnox	CO_2, 115, 333 (ex), 33,300	all critical, Pu prod
	CHAPELCROSS A & B (UKAEA)	O, C '58, '59	Annan, Scotland	—	140(4)	nat U, rod, Magnox	CO_2, 115, 333 (ex), 33,300	1 critical, Pu prod
	G-2, G-3 (CEA)	O, C '58, '59	Marcoule, France	—	60(2)	nat U, rod, Mg-Zr alloy	CO_2, 210, 309 (av), 100,000	
	SIBERIAN power station	O, C '58	Troitsk, USSR		600(6)	nat U, rod, Al alloy	H_2O	1 critical, Pu prod
	EDF–1 (Electricité de France)	C mid '59	Chinon, France		60	nat U, rod, Mg alloy	CO_2, 350, 355 (ex), 167,000	Pu prod
	BERKELEY (CEGB)	C mid '61	Berkeley, England	AEI—John Thompson	275(2)	nat U, rod, Magnox	CO_2, 140, 345 (ex), 381,000	3 further stations planned: Trawsfynydd (500), Dungeness (550), Sizewell (650)
	BRADWELL (CEGB)	C early '61	Bradwell, England	NPPC	300(2)	nat U, rod, Magnox	CO_2, 147, 390 (ex)	
	HUNTERSTON (SSEB)	C June '62	Ardrossan, Scotland	GEC/Simon-Carves	300(2)	nat U, rod, Magnox	CO_2, 165, 391 (ex), 354,000	
	HINKLEY POINT (CEGB)	C end '62	Bridgwater, England	English Electric Group	500(2)	nat U, rod, Magnox	CO_2, 200, 375 (ex), 600,000	
	AGR—Advanced Gas-Cooled Reactor (UKAEA)	C early '61	Windscale, England	—	28	UO_2 (1·25%), pellets, Be	CO_2, 285, 575 (ex)	
	LATINA power station (SIMEA)	C '62	Latina, Italy	NPPC/AGIP Nuc	200	nat U, rod, Magnox	CO_2, 390	
	URALS power station	C	Urals (Beloyarsk)		400(4)	U (1·3%), S.S. press. tubes	boiling H_2O, 2100, 355 superheat 1420, 530	nuclear superheat
	HALLAM nuclear power facility (AEC & Consumers' Public Power District)	C '62	Hallam, Nebraska	AI	75	U (2·3%), S.S.	Na, 61, 495 (ex), 15,450 gpm Na, 73, 477 (ex), 14,352 gpm	
	VOLGA Centre station	P	Ulyanovsk, USSR		50		Na, 1280, 500 (ex)	
	EDF–2 (Electricite de France)	C '61	Chinon, France		167	nat U, rod, Mg alloy	CO_2, 350, 355 (ex), 167,000	no containment vessel
PRESSURIZED WATER	SHIPPINGPORT (AEC & Duquesne Light Co)	O Dec '57	Shippingport, Pa	Westinghouse	60	seed: U/Zr alloy (90%) plates, Zircaloy-2 blan: UO_2 (nat), Zircaloy-2	H_2O, 2000, 272 (av), 377,000	with 2nd core 100 MW
	CONSOLIDATED EDISON THORIUM REACTOR	C late '60	Indian Point, NY	Babcock & Wilcox	255	UO_2/ThO_2 (>90%) pellets, Zircaloy-2	H_2O, 1515, 260 (av), 900,000	includes oil superheat 104 MW
	YANKEE ATOMIC Electric Co.	C late '60	Rowe, Mass	Westinghouse	110	UO_2 (3%) pellets, S.S.	H_2O, 2000, 268 (av), 635,000	with 2nd core to 135 MW
	VORONEZH station	C '60	Voronezh, USSR		420(2)	UO_2 (1·5%) pellets, Zr-Nb alloy	H_2O, 1420, 275, 1,000,000	identical station at Leningrad planned
	BTR—Belgian Thermal Reactor (Syndicat d'Etudes de l'Energie Nucléaire)	C '60	Mol, Belgium	Westinghouse	11·5			
	ENRICO FERMI project (SELNI)	P	Milan, Italy	Westinghouse	134			
	SIMEA project	P '62	Astura River, Italy	Vitro	150			

BOILING WATER	VBWR—Vallecitos Boiling Water Reactor (GE & Pacific Gas & Electric Co)	O	Aug '57	Pleasanton, Calif	GE	5	UO_2 (>90%), plates, S.S.	H_2O, 1000, 282 (av)	direct cycle
	DRESDEN (Commonwealth Edison)	C	late '59	Morris, Ill	GE	180	UO_2 (1·5%), rods, Zircaloy-2	H_2O, 1042, 285 (ex), 427,000	
	RWE—Rheinisch-Westfälisches Electrizitätswerk	C	'60	Kahl, Germany	AEG-GE	15	UO_2 (1·5%), rods, Zircaloy-2	H_2O	
	VOLGA Centre reactor	C	'61	Ulyanovsk, USSR		50	UO_2 (1·5%), Zr	H_2O	direct cycle, similar elements to PWR
	RURAL COOPERATIVE Power Assn & AEC	P	'60	Elk River, Minn	ACF	22	Th/UO_2	H_2O	separate superheat 7MWe
	NORTHERN STATES Power Co	P	'61	Sioux Falls, S. Dak	Allis-Chalmers	61·5	UO_2 (1·6%), plates, Al alloy	H_2O, 615, 255 (ex)	controlled recirculation; superheat (prob. nuclear) 16 MWt
	SANTA LUCIA power station (BANDES)	P	'61	Santa Lucia, Cuba	Mitchell Eng, AMF, GNE	22		H_2O	oil-fired superheat
	PACIFIC GAS & Electric Co	P	'62	Humboldt Bay, Calif	GE	60		H_2O	
	PROJECT ENSI—Energia Nucleare Sud Italia (SENN)	P	'62	Punta Fiume, Italy	GE	150	UO_2 (2%), Zr	H_2O, 1015, 286	
HEAVY WATER	RIII/ADAM (State Power Board, Stockholm)	P	'60	Nr Stockholm, Sweden	ASEA/Atomic Energy Co	15e 70t	UO_2, Zircaloy-2	D_2O, 495, 220 (ex)	70 MWt for district heating
	CHUGACH Elec Assn	P	'61	Anchorage, Alaska	Nuclear Dev Corp	10	U alloy (2%), rod, S.S.	Na, atm, 510 (ex), 38,300	
	CAROLINAS-VIRGINIA Nuclear Power Associates	P	'62	Parr Shoals, DC	Westinghouse	17			pressurized D_2O
	CZECH station	P	'63	Bohunice, Czechoslovakia		150	nat U, Be-Mg	CO_2, 850, 425	
	EAST CENTRAL & FLORIDA WEST COAST Nuclear Power Groups	P	'63	Florida	GNE	46	U (slight)	gas	high temp pressure tube; prototype for 200 MW station
FAST	ENRICO FERMI (Power Reactor Dev Co)	C	Sep '60	Lagoona Beach, Mich	Owner	90	core: U-Mo alloy (27%), pins, Zr blan: U-238. Mo alloy, pins, S.S.	Na, 92, 425 (ex), 220,000 Na, 30, 397 (ex), 220,000	
	BN-50	P		Ulyanovsk, USSR		50	Pu	Na, —, 480 (av), 128,000	construction on BN-250 to begin when BN-50 in operation
HOM. ORG.	CITY OF PIQUA & AEC	P	'61	Piqua, Ohio	AI	11·4	U (1·8%), plates, Al	Terphenyl, 35, 325 (ex), 12,000 gpm	
	PENNSYLVANIA POWER & Light Co	P	'63	Allenton, Pa	Westinghouse	70–150			construction decision in 18 months; breeder, Th slurry

ABBREVIATIONS

AEC—United States Atomic Energy Commission.
AEG—Allgemeine Elektrizitäts Gesellschaft.
AECL—Atomic Energy of Canada Ltd.
AGN—Aerojet-General Nucleonics.
AI—Atomics International.
AMF—AMF Atomics.
ANL—Argonne National Laboratory.
BANDES—Cuban National Bank for Social and Economic Development.
BNL—Brookhaven National Laboratory.
CEA—Commissariat à l'Energie Atomique.
CEAN—Centre d'Etudes pour les Applications de l'Energie Nucléaire.
CEGB—Central Electricity Generating Board.
ENEA—European Nuclear Energy Agency.
GE—General Electric Co. (of America).
GEC—The General Electric Co Ltd.
GNE—General Nuclear Engineering Co.
JENER—Joint Dutch-Norwegian Establishment for Nuclear Energy Research.
LASL—Los Alamos Scientific Laboratory
NRTS—National Research Testing Station.
NDA—Nuclear Development Corporation of America.
SELNI—Società Elettronucleare Italiana.
SENN—Società Elettronucleare Nazionale.
SIMEA—Società Italiana Meridionale Energia Atomica.
SORIN—Società Ricerche Impianti Nucleari.
SSEB—South of Scotland Electricity Board.
UKAEA—United Kingdom Atomic Energy Authority.
NPPC—Nuclear Power Plant Co.

POWER REACTOR EXPERIMENTS

	NAME and/or OWNER	STATUS	and FIRST LOADING	LOCATION	PRINCIPAL CONTRACTOR	TOTAL OUTPUT MWe or t	FUEL type (enrichment) form, cladding	COOLANT type, pressure (psia) temp (deg C) flow (lb/min)	NOTES
GRAPHITE	G-I (CEA)	O	'56	Marcoule, France	—	5e	nat U, Mg	air, atm, 220, 12,700	
	SRE—Sodium Reactor Experiment (AEC & S. Calif Edison Co.)	O	April '57	Santa Susana, Calif	AI	6e	U (2·8%), rod, S.S.	Na, 21, 515 (ex), 150	
	GCRE—High Temp. Gas-cooled exp. (AEC)	C	'59	NRTS, Idaho	Aerojet General	—			
	HTGR—High Temp. Gas-cooled Reactor (UKAEA—ENEA)	P		Winfrith Heath, England		10t		He	
	LMFRE-1—Liquid Metal Fuelled Reactor Experiment (AEC)	P			Babcock & Wilcox	5t			
PRESSURIZED WATER	APPR—Army Package Power Reactor (US Army)	O	April '57	Fort Belvoir, Va	Alco	2e	UO_2/S.S. alloy (highly), plates, S.S.	H_2O, 1215, 235 (ex), 27,000	APPR-2—twice thermal output—to be installed in Alaska by '60
	PORTABLE Russian plant	C	'59	Moscow (Obninsk)		2e		H_2O, 1710	
	LENIN icebreaker (USSR)	C	'59	—		180t (2)	UO_2 (5%), Zr alloy or S.S.	H_2O, 2850, 325, 36,670	third reactor 90 MWt reserve
	NS SAVANNAH passenger cargo vessel (AEC & Maritime Admin.)	C	'60	—	Babcock & Wilcox	63t	UO_2 (4%), pellet, S.S.	H_2O, 1750, 265, 30,000	
BOILING WATER	BORAX-4—Boiling Water Reactor Experiment (AEC)	O	'54	NRTS, Idaho	ANL	21t	ThO_2/UO_2, plate, Al-Ni alloy	H_2O, 315	direct cycle; Borax 1 dismantled, 2 modified to 3, ceased operation '56
	EBWR—Experimental Boiling Water (AEC)	O	Dec '56	Lemont, Ill	ANL	4·5e	U (1·44%), plate, Zircaloy-2	H_2O, 615, —, 62,000	with 2nd core 100 MWt
	ALPR—Argonne Low Power (AEC)	O	'58	NRTS, Idaho	ANL	0·2e 4t	U/Al alloy (highly), plates, Al-Ni alloy	H_2O, 315, 215, 16,700	packaged plant for remote areas
HEAVY WATER	ENERGIA NUCLEAIRE SA	P	'63	Nr. Lausanne, Switzerland		5e	UO_2 (1·4%), Zr	H_2O, 482, 250	underground
	NPD-II—Nuclear Power Demonstration (AECL & Hydro Elec. Power Comm.)	C	'61	Des Joachims, Ont	Canadian GE	17e	UO_2, Zr, pressure tubes	D_2O, 1115, 277, 86,000	dev. from NPD-1. Pilot for 200 MW plant
	HALDEN (Institutt for Atomenergi and ENEA	C	end '58 '59	Halden, Norway	IFA	10t	nat U, bar, Al	boiling D_2O, 570, 230	contained in rock
	SULZER project	P		Zürich, Switzerland	Sulzer Bros	30t	mostly nat U, Zircaloy, pressure tube	D_2O, 850, 220	electricity or district heating; underground
	HPTR—High Pressure Tube Reactor (AECL)	P			Canadian Westinghouse	130e	UO_2 in Zr tubes	D_2O	
FAST	EBR-1—Experimental Breeder Reactor (AEC)	O	'51	NRTS, Idaho	ANL	0·2e	core: U alloy (93%), rod, S.S. blan: Nat U, S.S.	NaK, 28, 318 (ex), 2,030 NaK, 35, 305 (ex), 2,030	
	BR-5	O	'58	USSR		5t	core: PuO_2, S.S. blan: B-U alloy, S.S.	Na—450 (ex) 130 cu m/h NaK—430 (ex) 130 cu m/h	experience for BN-50
	DFR—Dounreay Fast Reactor (UKAEA)	C	'59	Dounreay, Scotland	—	60t	core: U (enr), tube, Nb & Va blan: nat U, rod, S.S.	NaK—350 (ex), 52,000 NaK—325 (ex), 52,000	change to Na 18 months after comm.
	EBR-2 (AEC)	C	'59	NRTS, Idaho	ANL	17e	core: U alloy (49%) pin S.S. blan: depleted U, pin, S.S.	Na, 72, 480 (ex), 58,000 Na, 78, 469 (ex), 43,000	
	LAMPRE-1—Los Alamos Molten Plutonium Reactor Experiment (AEC)	P		Los Alamos, N Mex	LASL	1t	molten Pu		long-term project
HOM.	HRE-2—Homogeneous Reactor Experiment (AEC)	O	Dec '57	Oak Ridge, Tenn	ORNL	5t	UO_2SO_4/D_2O (>90%)	core: D_2O in soln., 1715, 300 (ex), 3,000 blan: D_2O, 1715, 283 (ex), 1,600	HRE-1 dismantled 1954
	LAPRE-2—Los Alamos Power Reactor Experiment (AEC)	C		Los Alamos, N Mex	LASL	1t			LAPRE-1 dismantled 1957
	VOLGA Centre	C		Ulyanovsk, USSR		35t	UO_2 in D_2O	D_2O	boiling cycle
	HOMOGENEOUS SUSPENSION (Reactor Centrum Nederland)	C			KEMA	0·25e	UO_2 in H_2O		
ORG.	OMRE—Organic Moderated Reactor Experiment (AEC)	O	'57	NRTS, Idaho	AI	5-15t	UO_2/S.S. alloy (highly), plates, S.S.	Terphenyl, 300, 275–375 (ex), 7,200 gpm	

HIGH POWER RESEARCH REACTORS

	NAME and/or OWNER	STATUS	FIRST LOADING	LOCATION	PRINCIPAL CONTRACTOR	THERMAL OUTPUT kW	MAX NEUTRON FLUX	FUEL type (enrichment) form, cladding	REFLECTOR	COOLANT	NOTES
HEAVY WATER	NRX (AECL)	O	'47	Chalk River, Canada		30	$6{\cdot}8 \times 10^{13}$	nat U, rod, Al	graphite	H_2O	original output 30 MW
	NRU (AECL)	O	'57	Chalk River, Canada		200	3×10^{14}	nat U, rod, Al	H_2O	D_2O	
	EL-3 (CEA)	O	'57	Saclay, France		15	10^{14}	U (highly)	D_2O & graphite	D_2O	
	DIDO (UKAEA)	O	'56	Harwell, England	Head Wrightson	10	10^{14}	U/Al alloy plates (90%) Al	graphite	D_2O	
	HIFAR—High Flux Australian Reactor (AAEC)	O	'58	Lucas Heights, Austr.	,,	,,	,,	,,	,,	,,	
	JULICH MTR	P	'61	Nr Cologne, Germany	,,	,,	,,	,,	,,	,,	
	PLUTO (UKAEA)	O	'57	Harwell, England	Head Wrightson	10	10^{14}	U/Al alloy plates (90%) Al	graphite	D_2O	fewer, larger exp. holes than DIDO
	DMTR—Dounreay Materials Testing Reactor (UKAEA)	O	'58	Dounreay, Scotland	,,	,,	,,	,,	,,	,,	
	DR-3—Danish Reactor	C	'59	Risö, Denmark	,,	,,	,,	,,	,,	,,	
	CHINA—Institute of Atomic Energy	O	'58	Peking, China	USSR	10					
	CIR—Canada India Reactor	C	'59	Trombay, India	Foundation Co	30	$6{\cdot}8 \times 10^{13}$				NRx type
	JRR-2—Japanese Research Reactor 2	C	'59	Tokai Mura, Japan	AMF	10	10^{14}	U (20%)			modification of CP-5
	JRR-3—Japanese Research Reactor 3	P	'60	Tokai Mura, Japan	Japanese design	10	10^{13}	nat U			
TANK	MTR—Materials Testing Reactor (AEC)	O	'52	NRTS, Idaho	Fluor Corp	40	5×10^{14}	U/Al alloy plates (93%) Al	Be	H_2O	has operated on Pu
	ETR—Engineering Test Reactor (AEC)	O	'57	NRTS, Idaho	Kaiser Engineers	175	7×10^{14}	U/Al alloy (93%), plates, Al	Be	H_2O	
	ORR—Oak Ridge Research Reactor (AEC)	O	'58	Oak Ridge, Tenn	ORNL	20–30	10^{14}	MTR type	Be	H_2O	Be-moderated
	R-2 (AB Atomenergi)	C	'59	Studsvik, Sweden	ACF	30	$2{\cdot}4 \times 10^{14}$	U/Al alloy (20–90%)	Be, D_2O, H_2O	H_2O	ORR type
	WWR-M (USSR)	C	'59	Nr Leningrad		10	10^{14}	UO_2/Al alloy (20%) tube, Al	Be	H_2O	
	WWR-Z (USSR)	C				10	10^{14}	UO_2/Al alloy (20%) tube, Al	Be & H_2O	H_2O	radiochemical research, greater fuel loading than WWR-M
	BR-2—Belgian CEAEN	C	'59	Mol, Belgium	NDA	50	6×10^{14}	U/Al alloy (90%) tubes, Al	Be	H_2O	
	RCN (Reactor Centrum Nederland)	C	'59	Petten, Netherlands	ACF	20	$1{\cdot}5 \times 10^{14}$	MTR type	Be	H_2O	modified ORR
	WTR—Westinghouse Test Reactor	C	'59	Waltz Mill, Pa	Owner	20					
	GETR (General Electric Co)	C	'59	Pleasanton, Calif	Owner	30					
	GERMANY MTR	C	'59	Karlsruhe		12					
	NACA-TR (National Advisory Committee for Aeronautics)	P	'59	Sandusky, Ohio	NACA	60					
	ITR (Industrial Testing Reactors Inc)	P	'60	Wadesboro, NC	GE	50					
	JAPAN MTR	P	'63	Tokai Mura, Japan		50		MTR type (90%)			
GRAPHITE	BEPO (UKAEA)	O	'48	Harwell, England		6	10^{12}	nat U bars, Al	graphite	air, once thro'	main British source of isotopes
	BROOKHAVEN Research Reactor (AEC)	O	'50	Upton, NY	H. K. Ferguson	30	3×10^{13}	MTR type	graphite	air, once thro'	
	RPT (Institute of Physics, Moscow)	O	'52	Moscow, USSR		15–20	$1{\cdot}8 \times 10^{14}$	UO_2/Al alloy (90%) tubes, Al	graphite & H_2O	H_2O	

LOW POWER RESEARCH REACTORS

	NAME and/or OWNER	STATUS and FIRST LOADING	LOCATION	PRINCIPAL CONTRACTOR	THERMAL OUTPUT kW	MAX NEUTRON FLUX	FUEL type (enrichment) form, cladding	REFLECTOR	COOLANT	NOTES
GRAPHITE	X-10 (AEC-ORNL)	O '43	Oak Ridge, Tenn	Clinton Lab	3800	$1{\cdot}12 \times 10^{12}$	nat U, rod, Al	graphite	air, once thro'	
	GLEEP—Graphite Low Energy Experimental Pile (UKAEA)	O '47	Harwell, England		10	$3{\cdot}7 \times 10^{10}$	nat U bars & UO_2 pellets, Al	graphite	air, once thro'	first in UK & still in use
	BR-1 (CEAEN)	O '56	Mol, Belgium		4000	$2{\cdot}1 \times 10^{12}$	nat U, bars, Al	graphite	air	similar to X-10
	ARGONAUT (AEC)	O '57	Lemont, Ill	ANL	10		UO_2/Al (20%), plates, Al	graphite	H_2O	Also in Argentina (RA-I) & 1 ordered by Siemens-Schutwerke
	JASON (Hawker Siddeley Nuclear Power Co Ltd)			Owner						Argonaut sold under license
	NERO	O '57	Harwell, England		—	$\sim 10^{8}$	U (slightly)			
	UTR-1 (American Radiator and Standard Sanitary Corp)	O '58	Mountain View, Calif	Owner	—					
	FLORIDA University	C	Gainesville, Fla	GNE	10					
	AMF-GNE Educator			AMF-GNE	10	10^{11}	U/Al alloy (20%), plates	graphite	H_2O	
SWIMMING POOL	SAPHIR	O '55	Wurenlingen, Switz	ORNL/Reactor Ltd	1000	$\sim 10^{12}$	MTR type (20%)	H_2O	H_2O	1955 Geneva Conference re-built
	PENNSYLVANIA State University	O '55	University Park, Pa	Owner	100		MTR type	H_2O	H_2O	to be increased to 1000 kW 10^{13} flux
	NRR—Naval Research Reactor (USN)	O '56	Washington, DC	Naval Research Lab	100			H_2O	H_2O	
	APSARA (AEC of India)	O '56	Trombay, India	AEC of India	1000		MTR type	H_2O	H_2O	
	(UKAEA)	O '56	Harwell, England		100	10^{12}	DIDO type	H_2O	H_2O	shielding experiments
	FORD Nuclear Reactor (Univ of Michigan)	O '57	Ann Arbor, Mich	B & W	1000			H_2O	H_2O	
	DELFT Technical University	O '57	Delft, Netherlands	AMF	100			H_2O	H_2O	originally on show at Het Atoom exhibition
	SAO PAULO University	O '57	Sao Paulo, Brazil	B & W	5000			H_2O	H_2O	
	PTR—Pool Test Reactor (AECL)	O '57	Chalk River, Canada	Canadair Ltd	100		U (90%), rod	H_2O	H_2O	
	ITR (USSR Academy of Sciences)	O '57	Moscow, USSR		2000	$3{\cdot}2 \times 10^{13}$	UO_2/Mg alloy (10%), rod, Al	H_2O	H_2O	similar reactors in Czecho-slovakia & Rumania
	NEPTUNE (UK Admiralty)	O '57	Harwell, England	Rolls Royce Ltd	—	$\sim 10^{8}$	U (enr)	H_2O	H_2O	Pressurized water, marine studies
	GERMAN SOCIETY for Utilization of Nuclear Energy in Shipbuilding & Navigation	O '58	Nr Hamburg, Germany	B & W	5000		MTR type (20%)	H_2O	H_2O	four special-purpose pools, marine research
	EWA (Polish Institute for Nuclear Research)	O '58	Nr Warsaw, Poland		2000		U (10%), Al	H_2O	H_2O	
	MELUSINE (CEA)	O '58	Grenoble, France		1200	10^{13}	U alloy plates (20%)	H_2O	H_2O	two working positions
	TRITON (CEA)	C '59	Fontenay aux Roses, France		1000	10^{13}	U alloy plates (20%)	H_2O	H_2O	
	MINERVE (CEA)	C '59	Fontenay aux Roses, France		—			H_2O	H_2O	

SWIMMING POOL	CURTIS-WRIGHT Corp	O	'58	Quehanna, Pa	Owner	1000			H_2O	H_2O	
	BATELLE Memorial Institute	O	'56	West Jefferson, Ohio	AMF	1000	$6{\cdot}6 \times 10^{12}$	MTR type (20%)	H_2O	H_2O	
	MUNICH Technical University	O	'57	Munich, Germany	"	"	"	"	"	"	
	McMASTER University	C	'59	Hamilton, Ontario,	"	"	"	"	"	"	convertible to 5000 MW
	ATHENS University	C	'59	Nr Athens, Greece	"	"	"	"	"	"	
	ISRAEL Atomic Energy Commission	C	'59	Tel Aviv, Israel	"	"	"	"	"	"	
	SORIN Nuclear Centre	C	'59	Chivasso, Italy	"	"	"	"	"	"	
	BUFFALO University	P	'59	Buffalo, NY	"	"		"	"	"	
	PORTUGUESE Nuclear Energy Board (UEN)	C	'59	Nr Lisbon, Portugal	"	"	"	"	"	"	
	INDUSTRIAL REACTOR Laboratories Inc	C	'59	Plainsboro, NJ	AMF	5000		MTR type	H_2O	H_2O	
	UNION CARBIDE Nuclear Co	C	'59	Stirling Forest, NY	"	"		"	"	"	
	AUSTRIAN STUDY CO for Atomic Energy	P	'59	Vienna, Austria	"	"		"	"	"	
	SPANISH Nuclear Energy Board	O	'58	Nr Madrid, Spain	GE	3000			H_2O	H_2O	
	TAIWAN National Tsin-Hua University	C	'59	Taipei, Taiwan	GE	1000		U (20%)	H_2O	H_2O	
	VENEZUELA Institute of Neurology and Brain Research	C	'59	Nr Caracas, Venezuela	"	"			H_2O	H_2O	
	VIRGINIA University	C	'59	Charlottesville, Va	Owner	1000			H_2O	H_2O	
	ORDNANCE MATERIALS Research Office	C	'59	Watertown, Mass	Owner	1000			H_2O	H_2O	
	MERLIN (AEI Ltd)	C	'59	Aldermaston, England	AEI Ltd	5000	5×10^{13}	DIDO type (93%)	H_2O	H_2O	
	HERALD (UKAEA)	C	'59	AWRE, Aldermaston	"	"	"	"	"	"	
	JULICH Research Centre	C	'59	Nr Cologne, Germany	"	"	"	"	"	"	
	BABCOCK & WILCOX Atomic Energy Division	P	'59	Lynchburg, Va	Owner	10			H_2O	H_2O	
	CORNELL University	P	'59	Ithaca, NY	Vitro	10			H_2O	H_2O	
	WASHINGTON STATE College	P	'59	Pullman, Wash	GE	100			H_2O	H_2O	
	AGN 211			Several under constr.	AGN	1-5 W	$2{\cdot}5 \times 10^{8}$	UO_2/polythene	graphite	H_2O	
	AGN 451				AGN	1 or 100	10^{8} or 10^{12}	UO_2/polythene	graphite/H_2O	H_2O	two cores available
HEAVY WATER	ZEEP—Zero Energy Experimental Pile (AECL)	O	'45	Chalk River, Canada		100	10^{6}	nat U, Al	graphite	—	
	EL-1 (ZOE) (CEA)	O	'48	Fontenay aux Roses, France		150	10^{12}	nat U, rod, Al	graphite	D_2O	
	TR (USSR)	O		Inst. of Heat Tech, USSR		2500	$2{\cdot}5 \times 10^{13}$	U (2%) annular	D_2O & graphite	D_2O	originally 500 KW
	JEEP (JENER—Dutch Norwegian Joint Establishment)	O	'51	Kjeller, Norway	Institutt for Atomenergi	500	$2{\cdot}2 \times 10^{12}$	nat U, rods, Al	graphite	D_2O	
	EL-2 (CEA)	O	'52	Saclay, France		2000	10^{13}	nat U	graphite	CO_2 at 7 atm	
	CP-5 (AEC)	O	'54	Lemont, Ill	ANL	2000	$\sim 10^{13}$	MTR type	D_2O & graphite	D_2O	
	RI (AB Atomenergi)	O	'54	Stockholm, Sweden		300	10^{12}	nat U, rods	graphite	air	
	DIMPLE (UKAEA)	O	'54	Harwell, England		—	$\sim 10^{8}$			—	
	MITR (Massachusetts Institute of Technology)	O	'58	Cambridge, Mass	ACF	1000		MTR type	D_2O & graphite		
	PRR—Pawling Research Reactor (NDA)	O	'58	Pawling, NY	NDA	5W	$\sim 10^{11}$	MTR type	graphite, Masonite	D_2O	can operate at 100W
	DIORIT (Reactor Ltd)	C	'59	Wurenlingen, Switz.	Owner	1200	2×10^{13}	nat U, rod, Al	graphite	D_2O	
	ISPRA-I (CNRN)	C	'59	Ispra, Italy	ACF	5000	8×10^{13}	MTR type	graphite	D_2O	modified CP-5
	ALIZE (CEA)	P	'59	Saclay, France		—		U (enr)			

LOW POWER RESEARCH REACTORS—*continued*

	NAME and/or OWNER	STATUS and FIRST LOADING	LOCATION	PRINCIPAL CONTRACTOR	THERMAL OUTPUT MW	MAX NEUTRON FLUX	FUEL type (enrichment) form cladding	REFLECTOR	COOLANT	NOTES
TANK	LITR—Low Intensity Test Reactor (AEC)	O '50	Oak Ridge, Tenn	ORNL	3000	3×10^{13}	MTR type	Be	H_2O	
	WWR-2 (USSR Academy of Sciences)	O '56	USSR		3000	4×10^{13}	U (10%), cylinders, Al	H_2O	H_2O	originally 300 KW
	OWR—Omega West Reactor (AEC)	O '56	Los Alamos, N Mex	LASL	1000		MTR type	H_2O	H_2O	
	LPTR—Livermore Pool Type Reactor (AEC)	O '57	Livermore, Calif	Foster Wheeler	1000					
	NEUTRON SOURCE Reactor (AEC)	O '58	Upton, NY	BNL	100					
	DR-2—Danish Reactor	C '59	Risö, Denmark	Foster Wheeler	5000			graphite		
	MRR—Brookhaven Medical Reactor (AEC)	C	Upton, NY	Daystrom	1000	$\sim 10^{11}$	MTR type	graphite	H_2O	
	SANDIA—Engineering Reactor Facility (AEC)	P '60	Sandia Base, N Mex	Sandia Corp	5000					
FAST	ZEPHYR	O '54	Harwell, England		—	$\sim 10^{9}$	Pu, rod, Ni blan: nat U		none	
	BR-1	O '55	USSR		—		Pu, rod, s.s. blan: U		none	
	BR-2	O '56	USSR		100	10^{14}	Pu, rod, s.s. blan: U		Hg	
	BR-5	O '58	Obninsk, USSR		500	10^{15}	PuO_2, pellet, s.s. blan: Ue Ni		Na	
AQUEOUS HOMOG.	SUPO (AEC)	O 50	Los Alamos, N Mex	LASL	45	1.7×10^{13}	UO_2SO_4 (90%)	graphite	H_2O	
	WBNS—Water Boiler Neutron Source (AEC)	O '52	Santa Susana, Calif	Al type L-55	—	$\sim 10^{10}$	UO_2SO_4/H_2O (20%)	graphite	H_2O	first operated at Downey, Calif
	LIWB—Livermore Water Boiler (AEC)	O '53	Livermore, Calif	Al	0.5	2×10^{10}	UO_2SO_4 (90%)	graphite	H_2O	
	APR (Armour Research Foundation)	O '56	Chicago, Ill	Al	50					
	RRR—Raleigh Research Reactor (North Carolina State College)	O '57	Raleigh, NC	Owner	0.5	2.5×10^{11}	UO_2SO_4 (90%)	graphite	H_2O	originally 10kW; new core in '57
	DR-1—Danish Reactor	O '57	Risö, Denmark	Al type L-54	—		UO_2SO_4/H_2O (20%)	graphite	H_2O	
	JRR-1—Japanese Research Reactor (Atomic Energy Research Institute)	O '57	Tokai Mura, Japan	Al type L-54	50	1.3×10^{13}	UO_2SO_4/H_2O (20%)	graphite	H_2O	
	GERMANY (Hoechst Farbwerke AG)	O '58	Frankfurt, Germany	"	"	"	"	"	"	
	GERMANY (Institute for Nuclear Research)	C '59	West Berlin, Germany	"	"	"	"	"	"	
	ITALY (Milan Technical University)	P '59	Milan, Italy	"	"	"	"	"	"	
	L77—Atomics International	O '58	Canoga Park, Calif	Al	10	2×10^{9}	UO_2SO_4/H_2O (20%)		H_2O	
	HAZEL (ZETR-II) (UKAEA)	O '58	Harwell, England		—	$\sim 10^{8}$	Uranylfluoride (90%)	graphite	D_2O	
SOLID HOMOG.	AGN 201		Some 25 under constr.	AGN	—	10^{8}–10^{10}	U (20%) in radiation stabilized polythene			
	TRIGA II		Several under constr.	General Dynamics	10–30	2.5×10^{13}	U/ZrH alloy (20%) plates, Al	graphite	H_2O	Zirconium hydride moderator; model at Geneva '58 sold to Belgian Congo
	IRGA			General Dynamics	10	10^{13}	U/ZrH alloy (20%), Al	graphite		
	REGA 10-30			General Dynamics	10–30	10^{13}	U/ZrH alloy (20%), cylinders, Al	graphite	H_2O	

A NUCLEAR POWER special report

Prospects for food irradiation

From a purely technical point of view there are a few products which could be treated now. But before they could be marketed there lie several hurdles

PROSPECTS for preserving food on a commercial scale by radiation treatment cannot be rated very high at present although there does seem quite a good chance that in combination with other processes it might have an economic future. This is the inescapable conclusion from the five-day symposium on the subject held at Harwell (Nov 17–21) under the auspices of the Food and Agriculture Organization of the United Nations. 'Cautious optimism'—in the words of R. S. Hannan (UK) who summed up the symposium—was the general feeling of most delegates but there was also a widespread appreciation of the inadequacy of our knowledge on the subject and demands for more international research cooperation.

Pasteurization now aim

It has been known for many years now that micro-organisms in food can be killed by ionizing radiation and that much work has been done on the subject—particularly in the US and the UK. Some of these, such as the more common meat parasites can be eliminated by relatively small doses but most of the yeasts, moulds and bacterial spores need very much more, certain of the latter surviving 2 megarads. Doses of this magnitude however have been found to introduce quite unacceptable changes in the odour, flavour, colour and texture of the food and sterilization—as the aim of the complete elimination of all microbial activity is called—has virtually been abandoned. Hannan in fact observed that there was little enthusiasm for any process using more than 1 megarad except in a few very special cases.

On the other hand, pasteurization—the eradication of most of the commoner microbial food spoilage agents—has proved technically feasible in a few instances and the meeting considered that the time was shortly approaching when commercial exploitation would be possible. Even here however, there were differences in opinion and it was apparent that the speakers from the United States—technically by far the most advanced country in this field—was more convinced than others. It should be noticed in passing that microbial activity is not the only factor causing food spoilage: enzymes and purely chemical changes also play a part and they are not affected by radiation.

Irradiation too is not by any means the only contender for food preservation and the meeting heard of some very promising new methods now under development such as freeze drying, antibiotic treatment and, specifically, the nonyl alcohol vapour treatment to prevent potato sprouting. This latter process is thought to be superior in the UK and irradiation work on potatoes has been terminated as it causes undesirable changes in quality.

The most promising irradiation application of all at the moment is the elimination of the food-poisoning *salmonella* in frozen egg pulp. Doses up to 0·5 megarad have been found adequate to suppress this without adverse effect and it is considered to be possibly the only way of doing this. It was however emphasized time and again that radio-pasteurized food must still be stored at under 5°C. This is because although the food spoiling agents may have been eliminated, dangerous bacterial spores such as *clostridium botulinum* are still present and would multiply quickly at room temperature. Dr Hannan remarked that one bad case of food poisoning from this cause could undo all the good work that has been done so far.

THE SCORE.....

possible now

- reproductive sterilization of insects in bulk grain (5000–10,000 rads)

shows promise

- inactivation of salmonella in frozen whole egg (0·5 megarad)
- extension of shelf life of certain meats, poultry and fish (up to 1 megarad)

doubtful finishers

- potato sprouting and milk preservation — both abandoned in Britain

Wholesomeness not proven

For all radiation processes, wholesomeness—meaning nutritional adequacy and freedom from harmful constituents—has not been fully proven although extensive feeding trials on animals and human volunteers have been in progress for some years, particularly in the US where the Quartermaster Food and Container Institute for the Armed Forces is in charge of all this work. With gamma or electron irradiation of moderate intensity there is no question of induced activity but the possibility of carcinogens and other long-term factors has not been disposed to the acceptance of any public health authority.

In many countries, irradiated food could not be sold at present owing to the food laws and legislative action would be necessary. Several countries are considering this but there was a general feeling at the symposium that some sort of international agreement should be aimed at. Assuming that wholesomeness can be proved and legislative problems settled there will still remain the task of selling irradiated food and this may not prove too easy in view of public suspicion of anything connected with radiation.

Despite the rather gloomy picture painted above, there is undoubtedly widespread enthusiasm among the workers in this field. Certainly a safe and economical method of preserving foodstuffs could have a tremendous effect on living standards and prevent untold waste. M. Vidal (France) for example pointed out that the annual loss to Europe from potatoes sprouting amounted to about 300 million francs. There is however clearly a tremendous amount of research still to be done.

The symposium concluded with a resolution that the FAO take steps with member countries to work out suitable methods of international cooperation on the technical and political levels. It was presided over by Dr R. A. Silow, chief of the FAO Atomic Energy Branch, Rome.

Many terms in common use in other connexions need precise definition when applied to liquid-cooled reactors

Boiling nomenclature —a plea for consistency

by H. A. ROBERTS and R. W. BOWRING,
Reactor Division, A.E.R.E., Harwell

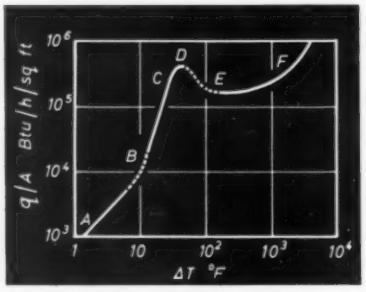
CLOSE ATTENTION has been given to boiling phenomena in recent years as a result of applications of boiling in liquid cooled reactors. Inevitably a new crop of terms has grown into use in this special field, some of which may appear confusing and obscure to the non-specialist. The time for a clean sweep has probably passed as the present nomenclature is too widely used in the considerable literature existing, yet future reporting can be clarified if unnecessary obscurities are removed by proper definition and standardization where necessary. R. P. Stein (*1*) has proposed admirable definitions, although some of the recommended terms appear to be unsuitable. We propose here modified terms and definitions, including others not dealt with by Stein.

Boiling and evaporation

First we must differentiate between boiling and evaporation: *evaporation* is the conversion of the liquid phase to the vapour phase; *boiling* is the formation of vapour within a continuous liquid phase.

Now consider the familiar curve of heat flux, q/A, from a submerged element, against temperature difference, $\triangle T$, between the heated surface and the bulk fluid at saturation temperature (*2*). A B, represents the part of the curve where heat transfer is by convection. The surface temperature at B is slightly above the saturation value, the excess being required to initiate vapour bubbles. The liquid in contact with the heated surface, being above saturation temperature, is said to be *superheated* by a certain number of *degrees of superheat*.

At B, boiling from the heater surface commences. At first, bubbles stream from one or two favoured points of nucleation, and these nucleating points become more numerous as the heat flux is raised. As the temperature difference is further increased up to and beyond its value at *D*, the bubble columns become more numerous and interfere with one another. The coalescing and clumping of the bubbles near the heated surface reduce the efficiency with which the heat can be removed, and as a result the heat flux actually decreases with increasing temperature difference. The maximum heat flux at D is known as the *critical* heat flux corresponding to the *citical temperature difference*. The use of the word 'critical' is not altogether desirable, but it is now in common usage and, in general, it is clear from the context what is meant. However, the term 'critical temperature' should never be used when referring to the temperature of the heater surface because of the possible confusion with the normally accepted meaning of the term.



Heat flux curve against temperature difference shows the different regimes of boiling

When the temperature difference is increased still further, radiation becomes significant and the heat flux increases again with temperature. The minimum value at E is known generally as the *minimum heat flux*.

The boiling curve may be divided into the different boiling regimes. AB is the *nonboiling regime* where heat is removed by the simpler single phase heat transfer process. The region BC represents the *surface nucleate boiling with vapour generation* regime, to give it a full descriptive title, although some of this may be dispensed with in normal writing. The word 'surface' is used to distinguish it from volume boiling, i.e. boiling within the bulk of the liquid, and 'nucleate' from film boiling. Stein's definition of nucleate boiling as a type of surface boiling is not satisfactory, as in volume boiling also a bubble is initiated at some kind of nucleus. The boiling regime CDE, in which both nucleate and film boiling take place, neither type being completely stable, has been variously named, e.g. partial nucleate boiling and unstable nucleate film boiling, partial film boiling, transition film boiling, and metastable film boiling. It is recommended that, as no term is outstandingly more popular than any other, *transition film boiling* be adopted as being the most descriptive. It is also least open to confusion, particularly with regard to the other transition region, i.e. non-boiling to nucleate boiling, where unstable conditions can also occur.

The meaning of burnout

The *burnout heat flux* is, literally, the heat flux at which a self-heated element—an electrically heated one, for instance, or a fuel element in a nuclear reactor—will burn out because of the heat flux. It may fail because it melts, or, in the case of an internally pressurized hollow element, because of rupture aided by a rise in temperature. Clearly the burnout heat flux cannot be related uniquely to any particular point in the boiling curve and may occur anywhere in the curve, depending upon the metal and the conditions of the experiment. In practice, however, burnout very often takes place when the critical heat flux is exceeded because the heat can then be removed only by a drastic rise in temperature to F, which may well cause melting of the heater. For this reason many authors, unfortunately, use *burnout* and *critical heat flux* as synonymous terms, frequently using the former where the latter would be more appropriate.

Much of the work in connexion with pressurized water reactors is concerned with surface boiling with the bulk water below saturation temperature. For convenience, and for want of a better name, this has been called *subcooled boiling*. The temperature difference between saturation and bulk water temperatures is the *degree of subcooling*.

References
1. R. P. Stein 'Definition of terms relating to boiling heat transfer' *Boiling Burnout Progress* No 7, NDA-22, 1955
2. Adapted from Figure 14-1, p. 370, *Heat Transmission* W. H. McAdams, 3rd Edn. (1954).

Neutron flux measurements in LIDO

by J. W. WEALE, H. R. McK. HYDER and others *A.E.R.E. Harwell*

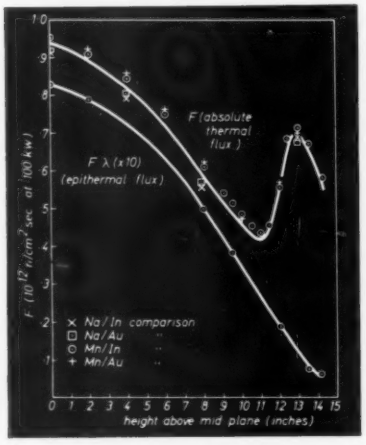
LIDO is a pool type reactor cooled and moderated by light water. The core is made up of MTR-type fuel elements mounted on a 3·025 in. pitch above a lattice plate. Each fuel element contains thirteen fuel plates, each consisting of a strip of uranium aluminium alloy clad in aluminium. The uranium is enriched to 46 pc in U-235, of which each plate contains 10 g.

Flux measurements were made, first so that reactor users could calculate the radiation fields in beam holes, experimental shields and other apparatus; secondly to allow core calculations to be verified experimentally and thirdly to compare the neutron spectra measured with a time-of-flight spectrometer with those deduced from activation measurements.

Foil activation

The first requirement was satisfied by measuring the thermal flux at many points throughout the core and in the reflector; the fast flux was measured at several selected positions. To compare theory and experiment absolute values of the fast and thermal flux distributions and fine structures were required along axes of symmetry in the core and reflector, while characterization of the neutron spectra demanded accurate measurements of the thermal and epithermal fluxes.

The measurements were made over a period when the reactor was being operated mainly at 100 kW for other experiments. The fuel elements were too active to be handled except under several feet of water and the detectors were therefore designed to be inserted readily into and removed from the


F (absolute thermal flux)
F λ (x10) (epithermal flux)
× Na/In comparison
□ Na/Au ..
○ Mn/In ..
+ Mn/Au ..
F (10^12 n/cm^2 sec at 100 kw)
height above mid plane (inches)

Vertical distribution of thermal and epithermal flux in the Harwell pool reactor

elements with handling tongs. Because the core of LIDO is small and compact and because the neutron flux in water-moderated systems varies considerably over short distances we decided to measure the fluxes with small foils which could be precisely located in the gaps between fuel plates. We used foils so thin that the corrections for flux depression and self-shielding were negligible. The absolute thermal and epithermal neutron fluxes were measured by irradiating thin foils of known mass under standard conditions and counting their activity in quartz-fibre electroscopes calibrated against standard sources or with coincidence counting equipment. The fast fluxes were deduced from the reaction rate of threshold activation detectors. In addition the relative intensities of thermal and epithermal fluxes were measured by the cadmium ratio method.

Maxwellian distribution

Absolute measurements of the fast, epithermal and thermal fluxes in LIDO have shown that the spectrum may be represented by a Maxwellian thermal distribution with the effective temperature about 20°C above the moderator temperature, by a dE/E slowing-down spectrum with a value of $\lambda = 0{\cdot}090$ in the centre of the core and by a fast spectrum only slightly different from a fission spectrum above 3·5 MeV. The absolute values of these fluxes are given as a function of position in the reactor core. As a result of the absolute measurement of reaction rates revised values of the indium activation cross section and of the manganese resonance integral are suggested.

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Degradation of plasticized p.v.c. compositions under high-level gamma radiation

by H. WELLS and I. WILLIAMSON *A.E.R.E. Harwell*

THE BUILDING of high activity handling cells has made it necessary to determine the useful life of certain polymeric based materials, which may be used as gaskets, washers, or protective coatings in close proximity to high levels of radiation.

To assess more accurately the useful life of these and to be in a better position to advise design engineers as to the formulation most desirable from a radiation aspect, a series of tests was carried out on plasticized p.v.c. samples to determine quantitatively the effect of formulation in preventing or retarding degradation.

P.v.c. film gradually darkens when exposed to gamma radiation. The discoloration proceeds through yellow to dark reddish brown and black and is commonly accepted to be caused by dehydrochlorination with the subsequent formation of conjugate double bonds in adjacent units of the polymer chain. Whatever the exact mechanism of degradation may be, it is accepted that p.v.c. formulations need to be stabilized against this effect if they are to have a useful life. There is a variety of organic sub-

stances compatible with p.v.c. and which exert a plasticizing effect on it. But other properties, such as migration, or ease of extraction with oil or detergents, must be considered if the formulation is to perform its correct function, e.g. as gasket or oil seal.

The most common commercial plasticizers are usually high molecular weight esters such as di-octyl phthalate, and the so-called non-migratory polymeric plasticizers such as polypropylene sebacate. After discussions with the Geigy Co it was decided to use the following plasticizers: (a) Reoplex 110 (b) Reoplex 100 (c) di-octyl phthalate (d) di-octyl sebacate (e) tri-tolyl phosphate. For the purpose of these initial tests, the percentage of plasticizer was constant at 40 parts by weight. The base polymer was Geon 101 with 5 parts by weight of white lead paste as stabilizer and no pigment or filler.

Cobalt irradiation

The irradiation was carried out using a Co-60 source. The mean level of radiation was 2×10^5 r/hour and the samples were exposed in a specially designed rack to receive integrated doses of $5{\cdot}0 \times 10^7$ and $1{\cdot}0 \times 10^8$ r.

As a result of mechanical tests the plasticizers fell into two groups; 1—D.O.P. and D.O.S.; 2—T.T.P., Reoplex 100 and Reoplex 110.

Compounds made from group 1 plasticizers lose both coherence (as measured by tensile product) and stiffness (as measured by modulus at break) under irradiation, and are not suitable where maintenance of physical properties is important. On the other hand, they show the least amount of colour change; at a radiation dose of 5×10^7 r both still show quite pale colours.

Loss of strength

Compounds made from group 2 plasticizers increase in stiffness on irradiation and show a smaller drop in tensile product. Where maintenance of physical properties is important, T.T.P. and Reoplex 110 from this group are to be preferred, T.T.P. being the better of the two. Using the tensile product as a criterion, the composition containing T.T.P. loses about half its strength after a dose of 5×10^7 r, and about 60% to 65% of its strength after 1×10^8 r. The stiffness of the T.T.P. composition increases by about 10% for 5×10^7 r and about 13% for 10×10^7 r. All three plasticizers in this group show very heavy darkening at 1×10^8 r; at 5×10^7 r the T.T.P. is noticeably lighter than the other two.

It also appears that the T.T.P. composition follows the same course of breakdown as the Reoplex compositions, but requires higher levels of irradiation to produce similar effects.

Further work in progress

The results indicate that p.v.c. compounds plasticized with tritolyl phosphate show less physical deterioration under gamma radiation than the other plasticizers tested. The two Reoplexes were second best, Reoplex 110 being better than Reoplex 100. The remaining two plasticizers were very poor.

Other properties do not necessarily correlate with physical (mechanical) deterioration. Di-octyl sebacate showed the least colour change and at ambient temperature was the most flexible of the irradiated samples.

Further samples calculated to investigate the effect of different fillers and stabilizers are being prepared and it is hoped that these will show even greater stability than those reported here.

This article is a condensed version of UKAEA report no. AERE E/R 2518. H.M.S.O price 3s. 6d.

Nuclear Technology | Irradiation

A review of gamma dosimetry methods

by D. B. DOVE *A.E.R.E. Wantage Radiation Laboratory*

A NEED exists for a simple reliable dosimeter suitable for routine control measurements in radiation processing. An effect suitable for dosimetry should be, within limits, independent of, or vary in a known manner with, dose rate, photon energy and environment, and be capable of reproducible measurement to the required degree of precision. Other properties, less essential but desirable in a process control dosimeter, are ease of measurement, low cost, chemical inertness, convenient size, ease of handling and good shelf life.

No general acceptance yet

Within the dose range of interest in food treatment, viz 10^4 to 10^7 rads, many systems of dosimetry have been proposed, which to a greater or lesser extent are suitable for process control, but none has yet received widespread acceptance. The following is a fairly comprehensive but not exhaustive compilation of reported systems.

Optical density dosimeters

(i) Glasses Silver phosphate glass darkens at a rate proportional to dose up to 10^5 rads; at higher doses sensitivity is reduced. The induced optical absorption is believed to be due to the formation of silver atoms within the glass due to silver ions acting as electron acceptors. There is a post-irradiation recovery which necessitates correcting for exposure time, and time lapse before measurement, although to some extent this fading may be stabilized by post-irradiation heat treatment (15 minutes at 100 deg C). The darkening may be erased by heating to 400 deg C, enabling the glass to be re-used.

Silicate glasses containing cobalt have been developed having good linearity of darkening up to 10^6 rads with much improved stability. A flatter energy response is also expected since the effective Z number is lower than that of the silver phosphate glass.

Antimonate glass shows no high dose saturation but actually increases in sensitivity above 10^7 rads. Post-irradiation heat treatment of 15 minutes at 125 deg C largely eliminates fading.

(ii) Plastics A commercial (du Pont) blue dyed cellophane film has been found to decolourize irreversibly upon irradiation. An increase in transmission of approximately 1·5% per megarad is observed due to breakdown of the dye. The film is cheap, storage properties are good, and there is no post-irradiation recovery. However, variations in film thickness (nominally 0·001 inch) and in dye concentration limit the accuracy.

Rigid non-plasticized p.v.c. film develops a post irradiation colouration proportional to dose to at least 6×10^6 rads. Full development of the colouration requires heating for 4 h at 120 deg F. The change is stable, film is cheap, available and easy to handle.

Films of p.v.c. having an incorporated indicator dye, methyl violet, have been prepared especially for dosimetry. The dye is radiation resistant but reacts with HCl liberated from the base material; dye retention vs. dose gives a straight line on a log-linear plot. These films cover the range 5×10^5 to 10^7 rads.

Experiments with polystyrene and

polymethacrylate show that the ultra violet absorption edge advances towards the visible region on irradiation. Increase in absorption measured at 4000 A is linear with dose up to 2×10^7 rads, however, post irradiation bleaching is appreciable, being 50% in four days for polystyrene.

Attention at Wantage Radiation Laboratory has concentrated on optical changes in commercially available materials, particularly on the radiation colouration reported to occur in ICI Red 400, $\frac{1}{8}$ in. perspex sheet. The radiation-induced absorption is proportional to dose up to 2×10^6 rads. Post-irradiation fading of the induced band occurs, but in adjacent parts of the spectrum a darkening takes place so it is possible to choose the measuring wavelength, or band of wavelengths, in such a way that fading and darkening cancel. The value so obtained is stable over a number of days; there is, however, a long term recovery due to diffusion and thermal effects.

Several dyes are known which decolourize irreversibly upon irradiation; these are, however, water soluble and are difficult to incorporate into a suitable base material. A solution to this problem might provide a dosimeter combining the handling properties of perspex with the stability of the du Pont cellophane.

(iii) Photographic film A special photographic print-out paper has been found which darkens with radiation up to 10^7 rads. The darkening is stable, but response depends slightly on dose rate.

Viscosity dosimeters

A 'go/no-go' device has been produced which consists of a capsule containing styrene polyester and a metal ball. The polyester gels with a sharp end point, i.e. after a certain dose has been received. Movement of the metal ball after inverting the capsule shows whether or not gelation has occurred, and so indicates whether or not the end point dose has been exceeded. About 30 minutes is required after irradiation for complete gelation.

The decrease in viscosity due to chain cleavage in polymers and in polymers in organic solvents, has been measured against dose. Flow times are measured at a standard temperature in a viscometer, and change of flow time vs. dose is approximately straight on a linear-log plot. The dose range covered extends to 10^8 rads.

Dye solution dosimeters

A resorcinal-stabilized chlorinated hydrocarbon-aqueous pH indicator dye system has been described for measurement of doses up to 10^6 rads. Readings are obtained by titration.

For high dose measurement dyes have been found which do not react with products of the solvent but which are decomposed directly by radiation. Such systems have reasonable sensitivity over the high dose range and are stable. Methylene blue in water has been used for some time, and more recently methyl yellow in cumene has been suggested. Although further work is required, such systems show promise for high dose measurement.

Luminescence dosimeters

The radiation degradation of an existing luminescence, and radiation induced luminescence, have been examined in various organic materials. The degradation of luminescence in anthracene occurs in the range ·3 to 10^6 to 200×10^6 rads and has been suggested for dosimetry.

The adoption of a system designed for dosimetry, such as the various glasses, will be influenced by eventual availability and cost. Several low cost commercial materials show useful radiation changes—e.g. Red 400 perspex, du Pont blue cellophane—but more work is needed before the full potentialities or limitations of these systems can be assessed.

This article is a condensed version of UKAEA report no. AERE I/R 2743. The full report contains an extensive bibliography.

Nuclear Technology Instrumentation

A neutron monitor for energies above 20 MeV

by P. D. HOLT and A. B. CLARKE *A.E.R.E. Harwell*

NEAR ACCELERATING MACHINES such as the Harwell cyclotron there is the possibility of a health hazard due to high energy neutrons. A method has been outlined for measuring weak fluxes of neutrons of energy greater than 20 MeV by exposing an anthracene crystal to the neutron flux, so that the reaction $^{12}C(n,2n)^{11}C$ is induced. The crystal is then removed and the 20·3 min. positron activity of carbon-11 counted by placing the crystal on a photomultiplier. The major difficulty, however, is the high background rate of the scintillation counter, due to its great sensitivity to terrestrial gamma radiation.

As originally constructed the counter used an EMI photomultiplier type 6260, with an aluminium reflector. A discriminator bias of about 0·2 MeV was used to reduce photomultiplier noise, the energy scale being roughly calibrated using the Compton maximum of a small cobalt-60 source.

Terrestrial gammas

Various steps were taken to reduce the background. A 4 in. steel castle reduced the background considerably, which showed that the chief component was terrestrial gamma radiation. A shield of GM counters in anticoincidence effected a reduction of 25 cpm, which represents the effect of cosmic ray particles. A reduction of 35 cpm was then obtained by using an EMI type 6097 photomultiplier instead of the 6260. This is because of the potassium-40 in the glass of the latter.

The present instrument is available for monitoring neutron fluxes at AERE of energy greater than 20 MeV with a minimum detectable flux of about $1 n/cm^2/sec$ and a statistical standard deviation on $\frac{1}{2}$ m.p.l. of 10·3%. There is an uncertainty of ±18% due to the $^{12}C(n,2n)^{11}C$ cross section; other errors are small compared with these two.

Portability limitations

At AERE the castle and electronic equipment are a semi-permanent installation. As far as any measurements away from Harwell are concerned, the equipment would have to be rather more transportable, and some accuracy would be lost. For instance the background counting rate using 2 inches of lead shielding, instead of 4 inches of steel, is 34 cpm, which gives a statistical standard deviation of 17·5% on $\frac{1}{2}$ m.p.l.

This article is a condensed version of UKAEA report no. AERE HP/R 2644, H.M.S.O. price 3s. 6d.

They said...

points from papers, speeches, conferences

Rethink on Calder

Control rods in the Central Electricity Generating Board reactors will have to be arranged to cope with varying power distribution in the cores, disclosed Sir John Cockcroft, the Atomic Energy Authority's Member for Scientific Research, during his recent visit to Tokio. 'The accumulation of radioactive xenon, a strong absorber, in large power reactors with a high power density can cause the power distribution in the reactor to vary', he said. The accumulation follows the decay of radioactive iodine produced during fission. A local increase in power density burns up some of the xenon, which results in an increase in local reactivity, and the disturbance will grow unless counteracted with increasing neutron losses by leakage. The net result is similar to that which arises if a reactor has a large positive moderator temperature coefficient since in this case also a local increase in power density will cause an increase in local reactivity. This has led to the provision of independent control mechanisms in separate zones of large reactors, and an automatically coupled temperature control system with a quick-acting response.

All designs modified

During the remainder of his lecture, which was entitled the British Nuclear Power Programme, Sir John revealed that modifications are being made to the AEA reactors to deal with the Wigner energy problem. 'We have found,' he said, 'that by sleeving the channels so that there is an insulating gas barrier between the fuel channel and the bulk of the graphite moderator we can raise the moderator temperature and eliminate periodic shut-downs for annealing. We are, therefore, starting with the Chapelcross reactors under construction, increasing the temperature in the coolest parts of the graphite by up to 90 deg C. This will ensure that on a conservative estimate over a 15-year life the stored energy will be less than 80% of the specific heat. Further, an increase of 20 deg C in the inlet temperature would mean that the stored energy would saturate well below the 80% figure.' In the civil stations now being constructed, the graphite temperature is already higher than in the Calder reactors and sleeving will ensure that the stored energy does not approach the specific heat for considerably longer than the minimum life of 20 years. Material for the sleeving is Magnox for the Calder and Chapelcross No 1 reactors. In the remaining Chapelcross plants and the CEGB stations graphite will be used.

BWR moves up

Even if a satisfactory method of superheating steam in boiling water reactors can be developed the advanced gas-

P. T. FLETCHER
We can afford it

cooled reactor is still a better economic proposition. This was the view advanced by the deputy managing director of the AEA Industrial Group, P. T. Fletcher, in a talk to the recent conference on Fuel and Power in British Industry at Manchester. At the same time, he thought a second reactor system should be developed to the commercial stage by the period 1965–1973, and the Authority is studying the boiling water and gas-cooled heavy water-moderated type in some detail. Though neither of these taken alone provides an economic alternative to the AGR, the BWR using superheated steam fed directly to a turbine would narrow the gap. If such a system can be developed and confidence established that steam may safely be delivered straight from a reactor to a turbine then it 'may well approach' the AGR in economic potential, offsetting higher fuel cost by saving the capital expense of a separate boiler.

The AGR and both the two possible starters would probably be capable of development to yield a reduction of at least £20 a kW on capital costs compared with the first round CEGB stations. Since the UK will probably install during the late 1960's and early 1970's about 10,000 MW of nuclear capacity, the potential saving over this period would be about £M200.

The interval between development investment and return of capital is usually about ten years and he argued that if a fourfold return on development costs over the same period of time were taken as a fair expectation this would justify spending from £M40 to £M50 on development work. Since the capital cost of building a prototype or experimental reactor is usually about £M10 and cost of the necessary ancillary plant and about a thousand man years of development effort amount to another £M10, 'it can be concluded that the UK programme could justify two lines of development. If returns are expected in the middle 1960's the prototype must either be in construction or soon to be started.' The AGR is under way and the AEA are considering what the second should be.

Looking further ahead to the middle and late 1970's, 'We cannot economically justify work on more than two in addition to those chosen for the shorter term programme. Of the two most promising, the fast reactor and the high temperature gas-cooled reactor, the first is the most important, and could produce power under base load conditions at less than 0·4d per unit in the early 70's.'

Ready and willing

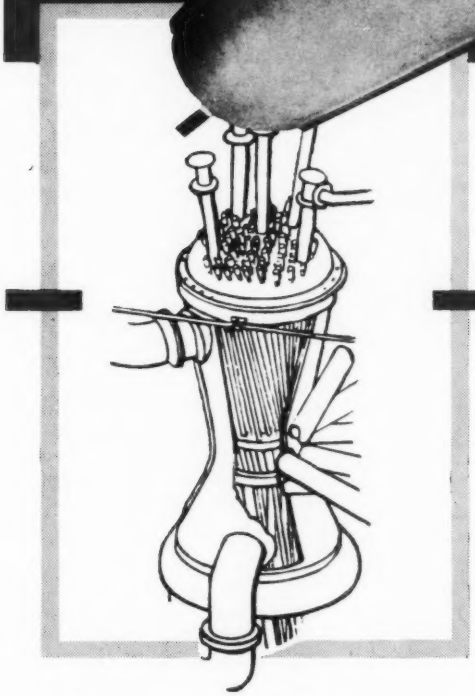
The only part of British power reactors which is not manufactured by industrial firms, pointed out Sir William Cook, AEA member for Engineering and Production, recently, is the fuel element, which is made in the Authority's own factories. Speaking to the European Atlantic Group in London on December 1 he said that the necessary standards of manufacture 'can only be sustained economically' with a large volume of production. All the same the Authority is willing to grant normal commercial licences 'at the appropriate time' to countries wishing to make their own fuel elements for reactors bought from Britain.

On the advanced gas-cooled reactor programme Sir William said that considerable development effort is being put into the problem of substituting plutonium for U-235. He confirmed that the early stations will be started with U-235 enrichment, but 'we hope to be able to change to plutonium enrichment when it begins to be available in large quantities as a by-product from the first generating stations, so that in the end we shall be dependent only on natural uranium and not on the expensive 235.

M & C NUCLEAR HELPS MAKE MORE NEUTRONS FOR BELGIUM WITH...

TUBULAR FUEL ELEMENTS

▲ FUEL ELEMENTS for the Materials Engineering Test Reactor, which is scheduled for completion at Mol in 1959 as Belgian Reactor 2, consist of six concentric tubes held by "spiders" at either end on a central irradiation tube. Water gap between tubes is 118 ± 15 mils. Each fuel tube consists of three flat plates formed and brazed together along their 38.671 ± 0.004 in. length; each plate has a core of U-Al alloy 20 mils thick with a double cladding of 15 ± 2 mils.



▲ The H_2O-cooled core of NDA's METR will produce irradiation fluxes of 2.4×10^{15} en/cm²/sec and 6.2×10^{14} tn/cm²/sec with a rated capacity of 50 Mw of heat. The skewed arrangement permits easy access to each fuel element and experiment during operation.

M & C NUCLEAR, INC. is pleased to be associated with Nuclear Development Corporation of America and Centre d'Etude de l'Energie Nucleaire in developing this new type of fuel element for the BR-2. This project is another example of cooperative effort by the designer, user, and fabricator of fuel elements — design and performance tests by NDA and CEN, fuel manufacturing development by M & C Nuclear. **M & C NUCLEAR, INC.** forms natural, depleted, and enriched uranium, thorium, and their alloys and cermets into a wide variety of shapes — including foil, plate, slab, disc, wire, rod, and tube — and assembles them into fuel elements and modules of many configurations. With its depth of experience in fabricating over 11,000 lbs of U^{235} into fuel elements, its 136,506-ft² facility, staff of approximately 850, and qualified vendors, M & C offers its services in developing and manufacturing fuel and core components for projects large or small.

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Cross Section by GRACCHUS

LIKE a miniature Geneva was FAO's Harwell food symposium, reported elsewhere in this issue. The Cockcroft Hall is really ideal for these meetings of 200-300 people and now it has been fitted with a simultaneous translation system, these international dos go off with a professional swing. I am always rather impressed with even the simplest conjuring tricks and I came back from Harwell really tickled over this one by the entomologists. One of the world's really big problems is the spoiling of stored grain by insects. Now these can be killed by radiation but it takes a lot and costs money, and what is proposed now is to eliminate the pests—by adding more! A normal insect population, like any other, consists of approximately equal numbers of males and females. If the balance is disturbed, say by introducing many more males, there commences a desperate competition for the females. Now here's the trick. If the extra males have all been sterilized—as they can be by quite a moderate dose of radiation—they will have no offspring. The multiplication constant will thus be reduced practically to vanishing point if the sterile males swamp the fertile ones and the race can be made to die out very quickly. What I didn't find out is how they tell a male from a female but I suppose it doesn't really matter because the irradiated females will also be sterile.

SO FAR no one has stuck their neck out in public on the intriguing question of a thermonuclear power station but I see from Amasa Bishop's fascinating recent book on the Sherwood programme that as far back as 1954 a Princeton team aided by GE and Westinghouse engineers had a good look at one. They did a design study on the Stellarator D to help them with the now-building Stellarator C. Assuming they could get continuous operation at 200M°K, the power stellarator tube would be 500 feet long, 3 ft dia. It would be surrounded by a 2 ft thick blanket consisting of closely-packed tubes, some carrying water and others lithium nitrite for tritium breeding. On top of this lot would be a 4 ft thick array of field coils. There would be a large diverter on each bend and magnetic pumping stations in each straight. 'All in all,' says Bishop, 'it was a sobering piece of equipment.' Total cost with generators etc, would have been close to £M1000 but the power output was estimated at over five million kW.

Bishop is a born science writer, I don't often agree with publishers' blurbs but in comparing his book with the Smyth Report I don't think they overreach themselves. The coloured diagrams are a joy.

Incidentally, why was the fusion programme declassified? Bishop gives as one good reason the fact that American reactor firms were getting rather worried about the future for fission and the amount of money they had invested. So the AEC thought it best to show them how difficult fusion really is. Apparently US industry is now reassured.

WITH thoughts of Euratom and ENEA very much in mind I went along the other night to the meeting of the European-Atlantic Group in Benjamin Wyatt's magnificent ballroom in Londonderry House. Reginald Maudling was down to speak and I was eager to hear what Britain proposes to do now about the Free Trade Area brainchild in view of France's apparent disenchantment with OEEC. But it was not to be. Sir Ian Horobin, deputising, pleaded a late division in the House for Maudling's absence, an excuse for which I've no doubt he was duly grateful.

The two main speakers were Emmanuel Sassen, a member of the Euratom Commission and the Marchese Cittadini Cesi, deputy Secretary-General of OEEC and beautifully diplomatic performances they gave. We also had Sir William Cook giving a brief run down of British domestic plans and Sir Claude Gibb stoutly defending the gas-cooled reactor against all comers. Sir Claude, who spoke last, introduced himself with a reference to going in last to bat. This went down well enough with the large genial audience but I could see the joke fell quite flat as far as the overseas visitors were concerned.

Afterwards, Mr Sassen told me he had good hopes that the Euratom/UK agreement—details of which had not then been revealed—would give Britain a real opportunity in the Community countries although it was nothing like as comprehensive and far-reaching as the US agreement. He also reminded me that when it comes into force on Jan 1 the Nuclear Common Market will abolish completely all tariffs—a thing which the Common Market will only achieve gradually. How Britain is going to benefit from this is not clear to me but perhaps the agreement will show how this will be done.

I asked Cittadini Cesi about a slight departure from his prepared speech and he confirmed that since it was written the last remaining hurdle to the joint high-temperature reactor experiment at Winfrith Heath had been overcome and there were now only a few matters of detail to be tidied up.

NO AMOUNT of salesmanship I imagine could have sold SENN a reactor they didn't really want, in view of Matteini's letter published in this issue. But I wonder if the British groups really put all they knew into this competition? I am told that the UK companies had quite an embarrassing time answering questions about positive temperature coefficients, zoned control rod groupings and ways of coping with Wigner energy. These all have the effect of complicating the essentially simple gas-cooled reactor but instead of coming straight out with a reassessment, news of these difficulties was allowed by the AEA and the British groups to leak out gradually and I'm told it created a very bad impression. Fuel too, I understand, played a part in the competition and the fact that Ansaldo are to make the second and subsequent ENSI cores was a trump card.

If Britain is to get a look in on the export scene a new and more aggressive attitude is needed both in the AEA and the contracting groups. In this connexion I see the Authority is now advertising for an overseas manager but the salary offered is hardly likely to attract the sort of tycoon needed for this task.

On record

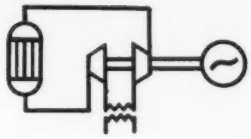
Our main objective at the moment must be to maintain the integrity of the OEEC.—Mr Reginald Maudling.

The last thing this country wants is a trade war with the six Common Market countries.—Sir Ivan A. R. Stedeford, Chairman, Tube Investments.

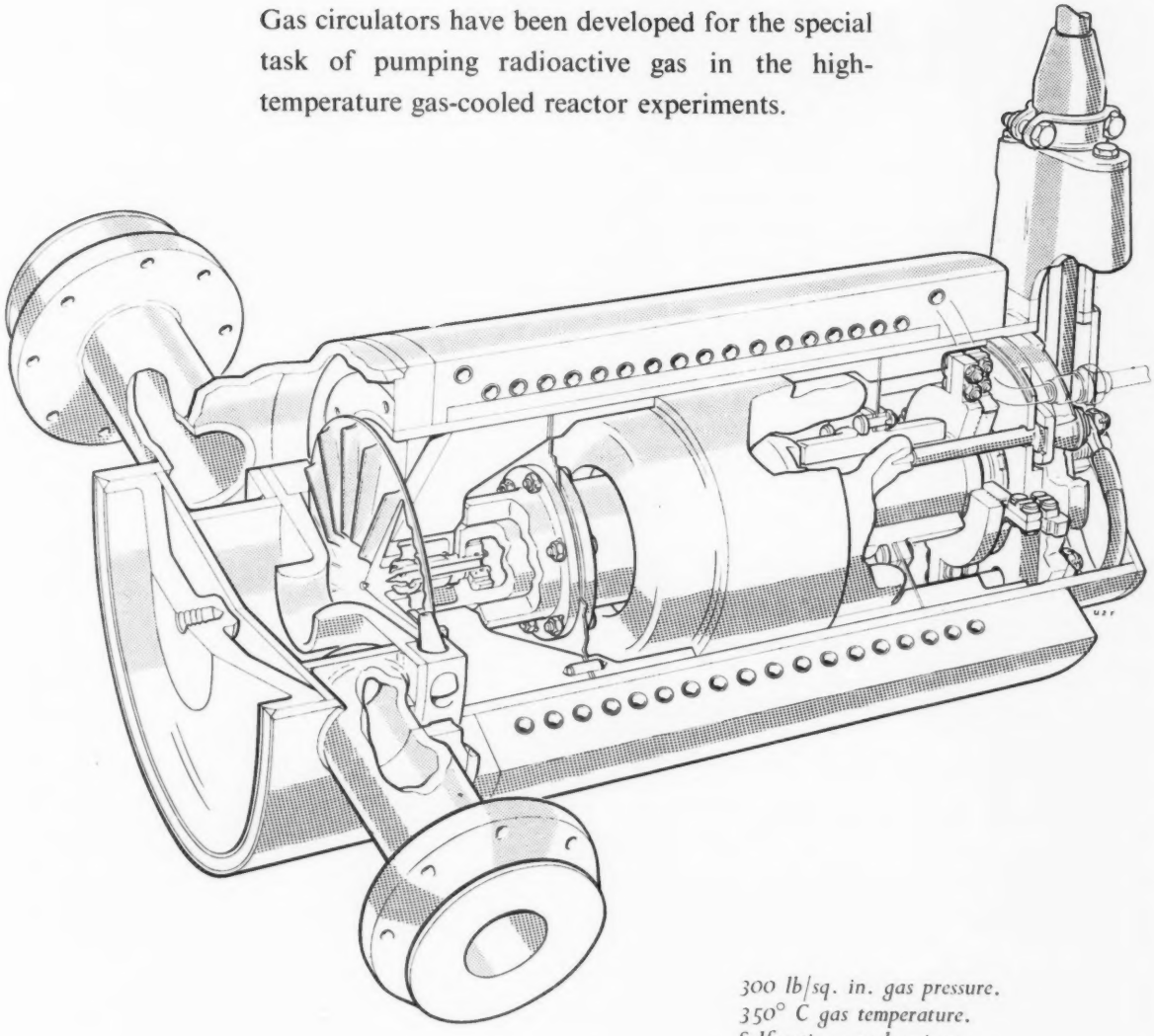
Everyone wants power but no one wants a pylon in his back garden.—Lord Mills.

Our recruiting methods are such that we are less likely than most organizations to find disruptive elements in our ranks.—Dr H. Rogan, UKAEA.

Towards the H T G C R –



Gas circulators have been developed for the special task of pumping radioactive gas in the high-temperature gas-cooled reactor experiments.



300 lb/sq. in. gas pressure.
350° C gas temperature.
Self-acting gas bearings.
Leak-tight all-welded casing.
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High-performance impeller—24,000 r.p.m.

DE HAVILLAND NUCLEAR POWER GROUP

The de Havilland Engine Company Limited Leavesden, Hertfordshire. *Telephone: Garston 4000.*

Tick **No 83** on reply card for further details

Training reactor operators

Generating Board to install simulator at Berkeley

A NUCLEAR reactor power plant simulator has recently been ordered from Elliott Bros by the Central Electricity Generating Board for delivery in July 1959. It will be installed initially at Berkeley power station and is designed to assist in the training of reactor operators for current and future series of nuclear power stations.

It is based on an electronic analogue computer, and the quantities simulated are all represented by voltages in the range −100 to +100 V d.c. Accordingly, instruments on the desk and boiler panels take the form of appropriately scaled voltmeters and self-balancing potentiometers.

The control desk is of similar shape and size to an actual reactor control desk and carries all plant controls and all the instruments except those on the steam and water side of the boilers. These include: indicators and recorders showing control rod positions; reactor power level on linear and logarithmic scales; power deviation from a chosen value; doubling time; coolant flow and fuel element temperature; coolant inlet and outlet temperatures; moderator temperature; generator load. Amongst the controls are raise/lower switches controlling reactor shut-off rods and control rods, blower speed, turbine steam valves, and boiler feedwater valves. A scram button, a reset trip button and a number of trip units operating on high flux, short doubling time, high fuel element temperature, etc, are also provided.

Separate computer cabinet

Controls are provided for the instructor to introduce disturbances for training purposes. These can be used to vary the reactor excess k either gradually or in a sudden step, to trip out one or both generators, to stop one blower, or to produce the effects of faults in the feedwater supply system. As they would not be available to an operator on a real plant, these controls are segregated on a small panel recessed into the end of the right-hand wing of the desk.

Only passive computing elements are mounted in the desk and the bulk of the computing elements including more than seventy drift corrected d.c. amplifiers and ten servo-multipliers, complete with power supply units and reference units, are contained in the computer cabinet.

Automatic rescaling

The simulator represents a graphite-moderated, gas-cooled, natural uranium-fuelled reactor. There are six blowers and six heat exchangers which supply two turboalternators working on a dual-pressure cycle.

Complete circuits are provided to compute the reactor power output and temperatures taking into account shut-down rod and control rod positions, inherent excess k, 6 groups of delayed neutrons, heat transfer and temperature coefficient effects, and xenon poisoning.

The machine is provided with an automatic rescaling system to make it possible to carry out start-up procedures covering more than 7 decades from the full shut down condition. It operates on ranges of from 40 W to 5 kW, from 5 kW to 5 MW and from 5 MW to 500 MW. About 1 second is taken for the rescaling process when the end of each range is reached.

Provision has been made for a scaling factor of 1/100 to be introduced into the power term fed to the reactor temperature computing circuits while the computer is on its middle range. The temperature computing circuits can thus be brought into operation in the middle range, and warming up commences at 5 kW.

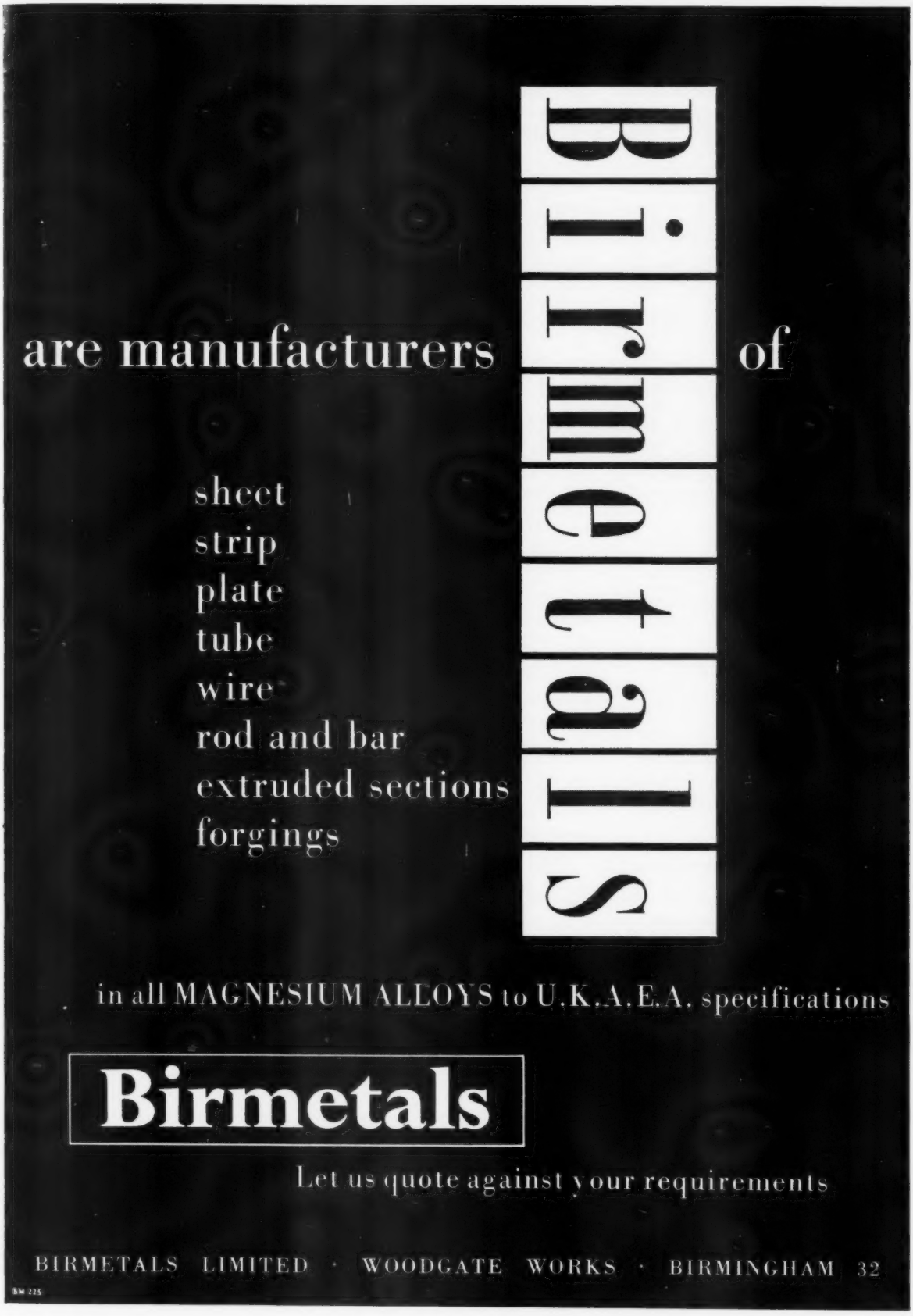
The reactor kinetics circuits are arranged so that a variable neutron source term may be introduced during start up, and a suitable control is provided for the operator. Normally, the source is effective on the lowest range only, being attenuated 100 times when the computer changes over to the middle range and disconnected on the high range. It can, however, be used with effectively 100,000 times its normal value in starting up the reactor directly on the high range by operating a 'rapid start-up' switch to reconnect it.

Alternatively, the simulator may be set on the high range and initial conditions of power, temperatures and delayed neutron populations set into the computing circuits.

Circuits are provided to compute the heat transfer and temperatures in the h.p. and l.p. economizers; evaporators and superheaters and the corresponding pressures, saturation temperatures and rates of evaporation. Further circuits determine the h.p. and l.p. drum water levels on the five 'good' boilers and the sixth 'failing' boiler. Simulated steam dumping valves are provided to dispose of steam generated in excess of the amount which can be used in the turbines either because it exceeds their ratings or because the electrical load has been disconnected.

Simulating plant faults

The turboalternators are simulated by circuits in which the steam flows are determined by the h.p. and l.p. steam valve openings and the boiler pressures. Generator loads are then estimated from the total heat delivered by the steam to each turbine multiplied by an efficiency factor. When either generator is tripped, the corresponding steam valve closes immediately and the load falls to zero. The boiler pressures will then rise and unless the other generator can absorb the extra steam or the reactor power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is reduced, the dumping valves will open.

The effects of the various fault conditions which can be initiated by the instructor are produced by introducing appropriate changes in the computing circuits. Thus when the sixth blower is caused to fail or the corresponding boiler is shut down, the simulated flow through the reactor is reduced to 5/6 of its former value, the steam flows are correspondingly reduced, and the pressures and temperatures in the shut down boiler slowly fall as it 'cools off.'

Under normal running conditions, the feedwater supplies to the boilers are controlled by a simulated automatic control system, but the instructor can cause the regulator valves on the h.p. and l.p. sections of boiler No 6 to jam shut or fully open, or the failure of the h.p. or l.p. feedwater supplies to all the boilers. When such a fault occurs, the feedwater flow and drum level indicators show the appropriate changes and the operator has to take action. This he can do by isolating the faulty sections of the plant and turning on manually controlled emergency supplies to replace the normal feeds.

The simulator can quickly be adjusted to represent any of the reactor power plants now being built, by means of preset potentiometers on the computer cabinet. Major changes to a fast reactor or one with a different fuel or moderator can also be made quite readily, if less conveniently, by changing component values in the computing circuits.

PROGRESS IN INDUSTRY

Radiation-resistant lubricants

by C. H. NAILER, *Shell-Mex and BP Ltd*

A WIDE RANGE of special lubricants has been developed in the UK over recent years by Shell for use in power plants and nuclear processing facilities. Here are some typical applications.

Gas circulators

Shell APL 729 was specially developed to meet the requirements of the gas seals of the main blowers at Calder Hall and other nuclear power stations now under construction.

Essential properties of the 85-sec oil are:

1. Low gas solubility
2. Low vapour pressure
3. Good oxidation stability
4. Good corrosion resistance

In addition to the gas seals, it is employed for the blower shaft bearings and the driving motors.

Gas valves

Large butterfly valves built into the main gas circulating systems of gas-cooled reactors are electrically operated through gear transmissions and driving shafts mounted in plain and rolling bearings. Components situated in close proximity to the valve are in contact with CO_2 and exposed to high temperatures, in some cases up to 250 deg C, and also subjected to gamma radiation.

Shell APL 701 is used for rolling bearings and APL 702, which is a graphited radiation-resistant grease, for heavily loaded gears, plain bearings, glands and couplings etc.

Control-rod drive units

The mechanisms within the control heads, situated in recesses in the biological shield over the top of the reactor are exposed to gamma radiation and fairly high temperatures in a CO_2 atmosphere. The bearings and lubricants are therefore required to operate for long periods without attention and, though for much of the time the mechanisms are idle or moving very slowly, complete freedom would be essential during emergency, high speed shut down.

Extensive tests have indicated that APL 701 grease gives good results in bearings running under conditions very similar to those expected in service. The control equipment on some reactors is operated electrically through oil-lubricated worm and spur gear transmissions. For such applications, APL 734 and 710 lubricating oils are used.

Reactor fuelling machines

Grease lubricated rolling bearings are employed in the winch mechanisms and tests have shown that APL 701 performs satisfactorily under the high temperature and radiation conditions. Grease lubricated components are employed where temperatures do not exceed 200 deg C.

When irradiated fuel elements are ejected, mechanisms may be operating in air and the bearing and gear lubricants must therefore possess good oxidation resistance.

Remote handling equipment

Remote controlled manipulators are used extensively in the nuclear engineering industry for handling radioactive materials. In the smaller types of manipulators, mainly used in research laboratories, the only lubricant required is a radiation-resistant grease for certain rolling bearings. The grade used extensively for such applications at Harwell, Dounreay and some establishments overseas is APL 700. In most cases the equipment operates under normal atmospheric conditions but within the hot cells it is subjected to gamma radiation.

Larger powered manipulators are operated either hydraulically or by electric motors. For these, APL 734 and 710 oils are used for spur and worm gear transmissions and APL 700 grease for rolling bearings, screw jacks etc. In the hydraulic system of one machine APL 742 fluid is employed.

Fault detection equipment

Samples of reactor gas are tested for activity as a means of locating any fault occurring in element canning materials. Electrically charged precipitator wires are used for this purpose and pulleys over which the wires pass have grease lubricated rolling bearings.

This equipment is subjected to gamma radiation and elevated temperatures and the lubricant must remain in service for prolonged periods without deterioration. To avoid excessive tension on the wires, low frictional resistance in the pulley bearing is essential. Also, as the apparatus functions in a CO_2 atmosphere, the lubricant must be non-reactive with the gas. At Calder Hall APL 701 grease is used for the pulleys.

Processing plant

This may include a wide range of equipment including slave manipulators for handling irradiated uranium fuel elements, machine tools, cutting and crushing machines installed in the process cells and operated by remote control. Much of this is subject to gamma radiation.

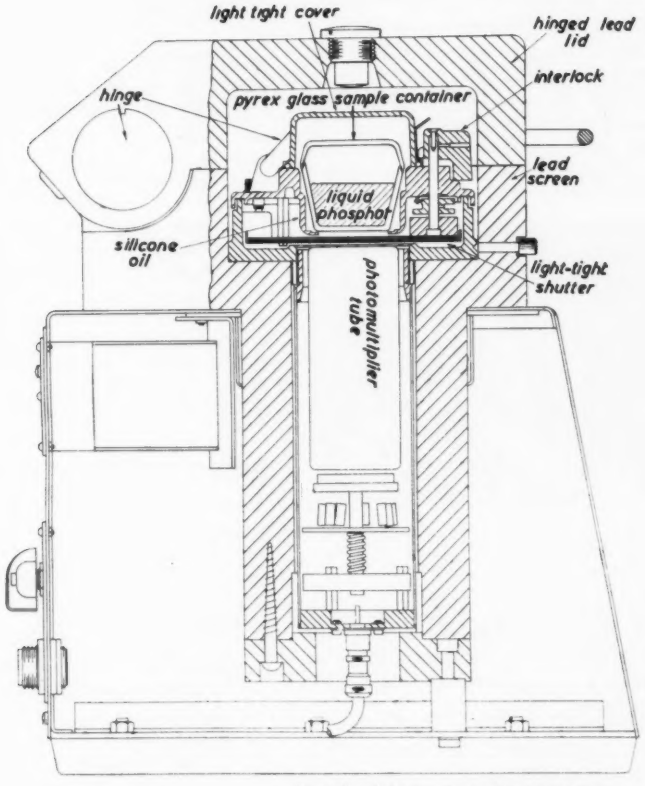
APL 731, 734 and 710 oils are employed for gear transmission systems in machine tools, cranes, and manipulators. Hydraulic controls systems are filled with APL 742 fluid and APL 700 grease is used for rolling bearings, grease-lubricated gears and many other components.

In some cases, machine parts are in contact with water and the water-repellent properties of the APL greases are therefore of great advantage.

very low energy

Beta measurement

EKCO *Type N612* scintillation counter



Reproduced by courtesy of Nuclear Power

Cross-section of the N612 scintillation counter showing sample pot in position

Measurement of low and very low energy Beta emitters, such as carbon 14 and hydrogen 3 (tritium), presents no difficulties with this specially designed Ekco scintillation counter which can be used with any scaler or ratemeter providing the necessary power supplies.

The sample, either dissolved in a liquid phosphor such as diphenyl-oxazole in toluene (PPO) or suspended in a 'gel' (PPO-Thixcin), is prepared in a small (about 25 ml) glass container.

To enable this counter to be used under normal lighting conditions, an interlocked shutter is incorporated which can be opened only when a lid is closed over the sample.

The sample chamber is shielded against external radiation from all directions by 2.5 cm. of lead and is contained, together with an amplifier, in a strong steel case which is fitted with carrying handles.

Write for full details of this and other EKCO instruments, to:—

EKCO ELECTRONICS LTD · **SOUTHEND-ON-SEA** · **ESSEX**

Tick No 85 on reply card for further details

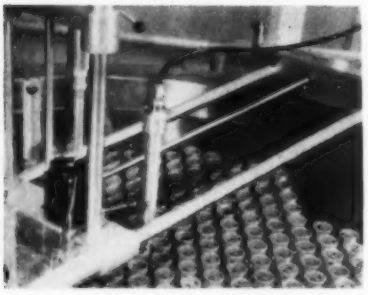
New Product Survey

PLANT · EQUIPMENT · INSTRUMENTS · MATERIALS

SCINTILLATION PROBE

uses new 10-stage p/m tube

Precision detection of fast or slow neutrons, gamma and beta radiation can be obtained by the Nuclear-Chicago DS-8 scintillation probe. Utilizing a new 10 stage, ½ in. photomultiplier tube and a transistorized electronic circuit, the basic detector weighs less than 5 ounces and



The DS-8 is used in Nuclear-Chicago's sub-critical training reactor to measure thermal neutron flux

is just 1 in. in diameter. It is completely watertight and corrosion proof. A resolution time in the microsecond region permits it use in extremely high radiation fields.

Accessories include a neutron probe ½ in. in diameter for flux measurements in reactors and subcritical assemblies. The neutron sensitive area is confined to the very end of the 42 in. probe so that 'point' measurements may be made easily. The probe housing is quickly removed to permit substitution of fast neutron or slow neutron sensitive phosphors.

Tick **No 185** on reply card

POWDER FLUXES

for submerged-arc welding

Under the generic name of *Muraflux*, Murex Welding Processes are producing a group of new powder fluxes for submerged-arc welding. *Muraflux A* is the first of these new fluxes, and it has been specially developed to meet the need for a high-quality general-purpose flux for the submerged-arc welding of mild steel. It can be used on either a.c. or d.c. supplies with welding currents up to 900 amp and on all machines suitable for submerged-arc welding.

The flux may be employed with a mild-steel filler wire containing approximately 2% manganese or with a normal mild-steel wire. Both types of wire, known as *Murawire W1* and *Murawire W2* respectively, can be supplied. When used with *Murawire, Muraflux A* produces good-quality welds of a high radiographic standard, and it can be employed for Class 1 work. In conjunction with *Murawire* the flux has been granted approval by Lloyd's Register of Shipping and is accepted by the Ministry of Transport.

Muraflux A is suitable for either the single-pass or multi-pass welding of various joints in mild steel, as well as plug welds and the building up of worn mild steel parts. Good penetration can be obtained, and unfused flux can be recovered and used again.

Tick **No 186** on reply card

IMPROVED FILM BADGE

1 and 13 week ranges

A new type of film badge is available from Tracerlab Inc. Known as the *Twin-film* the badge not only has the normal weekly film but another which is developed only every 13 weeks. According to Tracerlab president Samuel S. Auchinloss, 90% of people who work in a radioactive environment are not exposed to anything that can be measured on a weekly badge and so they have to assume they have had 20 mr—the lower limit of the film—whereas in fact they may have had none at all. In a year this uncertainty could amount to 1 roentgen and it has caused anxiety. By having a 13-week film, the assumed minimum exposure in a year is reduced to 1/13 roentgen.

As part of Tracerlab's film badge evaluation service they keep permanent records of individual exposure.

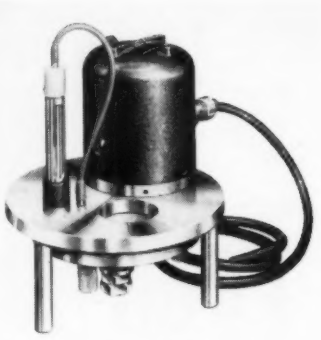
Tick **No 187** on reply card

WINDOWLESS FLOW COUNTER

for routine sampling

To meet the need for an instrument for routine counting applications where large numbers of solid samples of low energy beta-emitting isotopes such as carbon-14 or tritium are employed, 20th Century Electronics have just announced a windowless flow counter type WF2. This consists basically of a counting chamber beneath which is mounted a rotating sample holder. Each sample is treated in the following way:

On a suitable planchet, it is loaded on to the holder which is then rotated into a position where the gas from the counting chamber flows across the sample expelling any air or vapour. This is known as pre-flushing. The sample is then rotated to bring it under the count-



As a proportional counter argon-methane mixture is used: as a geiger, a commercial gas mixture

ing chamber and the measurement made. A further rotation of the holder permits the sample to be changed. In this way one sample is being counted while the next is being pre-flushed.

The principal advantage claimed is the increased counting efficiency due to improved sample counter geometry, and the lack of window absorption. This increased counting efficiency also enables more rapid counting of samples due to the shorter counting time required for a given accuracy.

Tick **No 188** on reply card

AUTOMATIC RADIATION MONITOR

buzzer and light warnings

A new compact, bench-type radioactive detector by Borg-Warner International is said to provide effective warning and environmental monitoring of beta and gamma radiation in laboratory areas. The unit, called the Automatic Radiation Supervisor, is designed for portable, instant use. Among its applications, the unit may be used to monitor background in low-level counting rooms, in the working areas of hot laboratories, and in industrial radiography installations. The unit incorporates simplified plug-in design and utilizes positive buzzer and lamp indications.

In operation, when radioactive background arises, an audible buzzer sounds and a red warning light flashes. A built-in time delay circuit—said to prevent false alarms—is incorporated into the design. A Halogen-Infinite-Life GM tube, employed as a sensing element, plugs directly into the rear of the

continued on p 138

This is one of a series of advertisements by ***RITCHIE CALDER*** *which is appearing in the National Press to illustrate how atomic power is helping to open up the frozen wastes of the Arctic*

Mosquitoes Traced by Radioactive Nectar

PEOPLE do not usually associate mosquitoes with the Frozen North, but Arctic Old Hands will tell a tenderfoot: 'Mosquitoes! They are so big we skewer them on spigots and roast them!'

That is an exaggeration, but they are certainly 'man-eaters'. Fortunately they do not, like the anopheles of the tropics, transmit malaria; but when the icebound swamps unfreeze in the Arctic summer they swarm in such vast numbers, and bite with such blood-thirsty persistence, that the settlers' lives become unbearable. Indeed, it can be said that the mosquitoes are a bigger obstacle to settlement and development of Arctic regions than the cold or the six-month long night.

RADIOACTIVE ISOTOPES

Something will have to be done about these hostile and voracious insects. Already scientists are hard at work studying their habits. Ingenious methods are being devised to keep track of the swarms, not the least of which enlists the help of nuclear energy.

It is known that the mosquitoes drink the nectar of the Arctic poppies (again, people do not usually associate flowers with the Frozen North) and the experts are feeding the poppies with an artificial fertiliser containing radioactive isotopes, which are, of course, by-products of the release of atomic energy.

In the Arctic poppy then, this radioactive fertiliser finds its way into the nectar. The mosquitoes sipping the nectar, pick up the radioactive elements. And from there on, they are marked. They carry in their bodies a 'radio transmitter' and the scientists can follow them wherever they go and so find out vital information concerning their habits — information that will lead to their effective control.

The end result of using this by-product of nuclear energy to plot the mosquitoes' activities will help to make the Frozen North a more comfortable place in which to live and work. And this, in turn, is an important factor in preparing the way for the time when atomic power itself releases the immense industrial resources of the Far North.

MITCHELL ENGINEERING *are designing and constructing Nuclear Power Plant to meet world needs in the New Atomic Age*

MITCHELL

MITCHELL ENGINEERING LIMITED · ONE BEDFORD SQUARE LONDON

This was the shape of

# of oil after radiation

Here was a problem of national importance. Lubricants were needed by the nuclear industry for reactor equipment, much of it subjected to radiation. Yet, like human beings, oils and greases were vulnerable to radiation. Oils darkened in colour and became coarse-grained solids (solidification being but one of a tangled skein of problems).

The Shell Group started working on the problems of lubricating under radiation conditions while most nuclear power stations were still on the drawing board. In fact, Shell was the first oil company to develop Atomic Power Lubricants, and the research that went into Shell A.P.L. is characteristic of the way Shell sets about doing things. A team of research workers was assembled at Shell's Research Centre at Thornton. Series of tests were carried out both in the B.E.P.O. pile at the U.K. Atomic Energy Authority Research Establishment, Harwell, and with Thornton's own Cobalt 60 source of radiation. In 1957, after four years of research, Britain's first range of Atomic Power Lubricants was on the market.

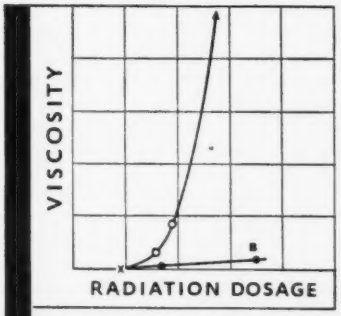
The moral of the A.P.L. story is that Shell research is supremely applicational. The Centre at Thornton is always ready to work with even the most specialised sectors of industry to produce the right oil for the job. If you and your organisation have any major lubrication problems, it will pay you to get in touch with your local distributor of Shell Industrial Lubricants.

The Research Story

In the hundreds of complex hydrocarbons examined, very different reactions to radiation were observed according to the configuration of the atoms in the molecules. When carbon atoms were arranged in long, straight chains, radiation caused these chains to link up with one another, giving highly complex structures of an entirely different nature from the original material. The first effect of this change was to cause a rapid increase in viscosity, ultimately giving rise to a solid rubber-like product.

For example, a high quality turbine oil conforming to BSS.489 receiving a dosage of 1.77×10^{18} neutrons/cm^2 was changed into an intractable solid—a clear demonstration that radically new lubricants were needed by the nuclear industry.

Shell Atomic Power Lubricants have a molecular structure that has proved itself very resistant to radiation. In fact it will withstand a radiation dosage four million times stronger than that which will kill a man—without any significant change in structure or physical properties.



Relationship between radiation dosage and percentage increase in viscosity, cS at 100°F.
Oil A: high molecular weight long chain hydrocarbon. *Oil B:* Shell A.P.L. 731.

SHELL

ATOMIC POWER LUBRICANTS

another proof of Shell leadership in Lubrication

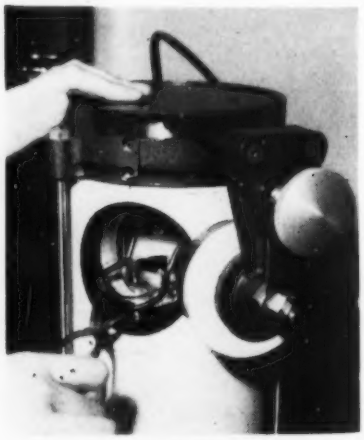
Tick **No 88** on reply card for further details

chassis. Provision is made for remote monitoring, and the unit is easily movable from one location to another.
Tick **No 189** on reply card

LIQUID SCINTILLATION COUNTER

tritium and C-14 applications

The SC/LP scintillation counter which is now being marketed by Panax Equipment Ltd has been developed for the counting of millimicrocurie quantities of very low-energy beta-radiation emitters such as tritium and carbon-14. The



As the light-tight door is opened an e.h.t. switch and shutter automatically shield the photomultiplier

counter is intended primarily for use with liquid phosphors but can also be converted to accommodate plastic phosphors and sodium iodide crystals. The equipment consists of a 1½ in. thick (minimum) lead castle fitted with a light-tight door which is interlocked with an EHT switch and a shutter assembly to protect the photomultiplier and to prevent external light increasing the background count.

Normally, a standard 30 ml glass jar is used as a container for the liquid phosphor into which the radioactive source to be counted is placed: since the shutter provided opens automatically when the castle door is closed and operates a microswitch, samples can be changed in normal room lighting while maintaining a low level of background counts. When in position in the castle, the bottom surface of the glass container is adjacent to the sensitive surface of the photomultiplier tube and a good optical contact is maintained by means of a liquid light guide. The shutter assembly can be replaced by a crystal mount which will accept 1½ in. dia. by 1 in. sodium iodide crystals or plastic phosphors of similar dimensions: by inverting the unit, liquid and solid samples can be investigated with minimum air gap between sample and detector. The high efficiency counting of low-energy beta-emitters in other forms can also be carried out with this equipment.

For counting purposes, the counter is used in conjunction with a linear amplifier and suitable scaling apparatus incorporating discriminator and EHT supplies. Efficiencies of 10% for tritium and 50% for carbon-14 have been obtained at room temperature, but higher counting efficiencies can be achieved by cooling the castle in a standard refrigerator.
Tick **No 190** on reply card

GROUND CONTAMINATION MONITORS

twelve for Harwell

An order for 12 special ground contamination monitors has recently been completed by Elliott Bros for the AERE Harwell. These will be erected at intervals round the perimeter of the Estab-

The monitor is ruggedly built in alloy castings. It's designed for permanent installation round nuclear plants

lishment as a permanent installation and will provide records of airborne radioactivity reaching the ground.

The monitor head is mounted 3 ft above the ground and is arranged to 'see' a certain area below. It contains two halogen-quenched geiger counters, one of which is screened against betas. Thus readings are obtained of gammas only and betas-plus-gammas. The signals are measured on a cold-cathode ratemeter working in conjunction with a magnetic amplifier. Counts are recorded on a pair of mechanical counters and there is also a 7-day circular chart. The maximum count catered for is about 200 per sec, or 100 times normal background.

A further development on hand at Elliotts is a monitor using a transistorized ratemeter and scaler mounted in the head unit with provision for centralized recording.
Tick **No 191** on reply card

In Brief

Cercor structures Extremely thin-walled ceramics formed into lightweight honeycomb structures capable of operating at high temperatures have been introduced by Corning Glass Works. Made by the new Cercor process, these materials can withstand temperatures up to 1000°C with virtually no thermal expansion, and can operate continuously at 700°C.
Tick **No 192** on reply card

Industrial cleaner Specifically designed for continuous heavy duty operation is the Bivac industrial vacuum cleaner, model CL. 'Clear-flo' filter will return particles down to 0·1 micron and filter life of two years is guaranteed. Standard version is powered by 5 h.p. electric motor but other sizes and petrol engines can be fitted.
Tick **No 193** on reply card

Level control A new capacitance-operated level control and induction equipment introduced by Lancashire Dynamo Electronic Products Ltd. Single-level and multi-level units—both transistorized—can be used with granulated solids as well as liquids.
Tick **No 194** on reply card

Pocket multimeter Compact and easily portable multimeter by Metrix (type 460) has 28 ranges including: voltage 0–750 V a.c. and d.c., current 20 microamp to 1·5 amp a.c. and d.c., resistance 0–2 megohm in 2 ranges.
Tick **No 195** on reply card

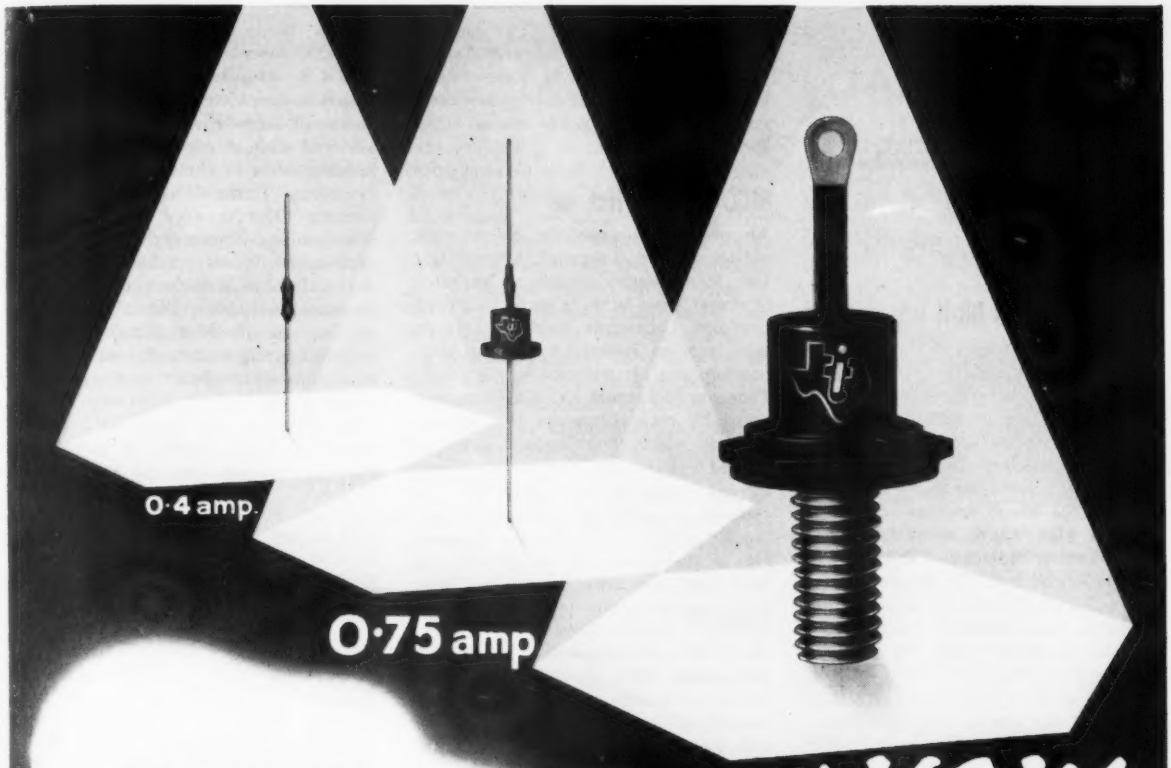
Temperature control For keeping temperature of liquids and gases at predetermined temperatures between −4° and +572°F, the *Kosmos* regulator is now available in this country.
Tick **No 196** on reply card

Air filters Fibreglass have produced two new types—V4 and V5. Initial efficiencies claimed with Test Dust No 2 are: V4—90% V5—98%. They require no maintenance and the replacement cost is low.
Tick **No 197** on reply card

Flexible pressure hose Polypenco Ltd's new *Nylaflow* consists of special polyamide (nylon) inner tube reinforced with high tensile outer yarn. It's available in two pressures—8000 and 5000 psi.
Tick **No 198** on reply card

Heavy-duty pneumatic valves New models from Martonair are available in 3- and 5-port forms.
Tick **No 199** on reply card

Cold-cathode tube A new sub-miniature triode by Hivac Ltd the XC23—gives an increased current rating over the XC18.
Tick **No 200** on reply card



SILICON RECTIFIERS

200-600 volt P.I.V.

and NOW 3·0 amp.

This new Texas diffused junction silicon rectifier gives you full 3-ampere output at 50°C. with P.I.V. ratings up to 600 volts. The all-welded rugged construction with glass to metal seal, provides high resistance to shock and vibration.

Anode-to-stud units denoted by "R" suffix to type number.

U.K. Nos.: / U.S.A. Nos.:	1S401 1N1124	1S402 1N1125	1S403 1N1126	1S404 1N1127	1S405 1N1128	unit
MAXIMUM RATINGS						
Peak Inverse Voltage at —65°C to +150°C	200	300	400	500	600	V
*Average Rectified Forward Current at +50°C	3	3	3	3	3	Amp
*Average Rectified Forward Current at +150°C	1	1	1	1	1	Amp
*Recurrent Peak Forward Current at +50°C	10	10	10	10	10	Amp
Surge Current, for 5 milliseconds at +25°C	25	25	25	25	25	Amp
Operating Temperature, Ambient	—65+150					°C
SPECIFICATIONS						
Max. Full Cycle Avg. Reverse Current at +150°C	0.3	0.3	0.3	0.3	0.3	mA
Max. Reverse Current at PIV at +25°C	10	10	10	10	10	μA
Max. Forward Voltage Drop at I_b = 1 Amp at +25°C	1.1	1.1	1.1	1.1	1.1	V

* Rectifier mounted on 2" × 2" Heat Sink, 1/16" aluminium.

Actual Size

Full information on all Texas Rectifiers available on request.

TEXAS INSTRUMENTS LIMITED

Pioneers of Semiconductors

T20 DALLAS ROAD, BEDFORD. TEL: BEDFORD 68051. CABLES: TEXINLIM BEDFORD

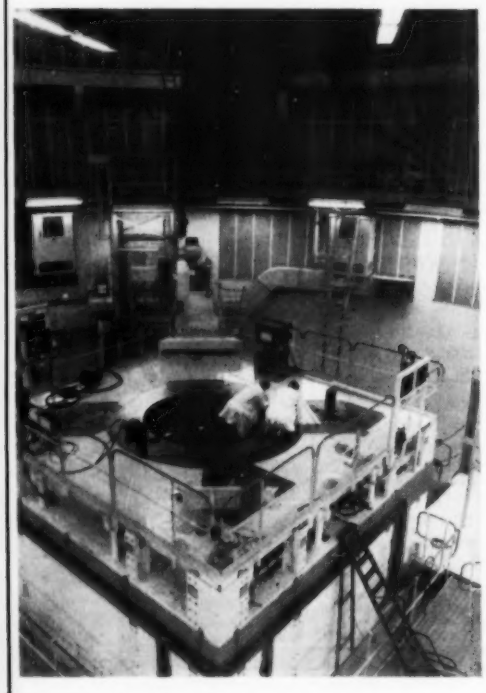
INDUSTRIAL NEWSDESK

UK firm supplies BR-II instruments

Reactor control ionization chambers and fission chambers for the Belgian high flux materials and engineering test reactor BR-II and its associated core mock-up facility are being made by the British 20th Century Electronics. The ionization chambers are type RC6 which contain enriched boron coatings and incorporate a high degree of compensation against gamma radiation. The coating is being produced from the isotope separation units which were installed at the company's New Addington factory under a 10-year agreement with the UKAEA (*Newsdesk* October); the process includes the preparation of high purity elemental boron used for coating the chambers.

20th Century Electronics have already sent off the first shipment. Contracts for the complete instrumentation of the reactor—due critical late in 1959—are in the hands of Ateliers de Constructions Electriques de Charleroi, who are licensees of 20th Century Electronics in the Benelux countries.

DMTR GOES ON FULL POWER Second of the Pluto heavy water reactors and the highest flux type in Europe outside Harwell, Dounreay's Materials Testing Reactor went up to full power in mid-December. First loop experiments will start after Christmas



BICC—Telcon link up

An offer to acquire the entire share capital of the Telegraph Construction and Maintenance Co on an exchange of shares basis is to be made by British Insulated Callender's Cables. This results from an investigation by an independent firm of chartered accountants—Thomson McLintock and Co—who were asked by both companies to suggest a basis on which their interests might be merged. The two firms have been actively cooperating in the UK and overseas for some years. Main potential benefits of the merger are the broadening of their base on the metals side, their respective interests in these fields being complementary to each other, coordination of research and development effort, the rationalization of production and sale in fields in which both companies are interested, and the complete dovetailing of their interests in overseas investments.

International trade eased

The new Customs and Excise Tariff, based on the internationally agreed classification known as the Brussels Nomenclature, comes into operation on January 1. Of the twenty-two member countries of the Customs Cooperation Council at Brussels the UK will be the fourth to adopt the nomenclature; France, Germany and Austria have already introduced tariffs based on this classification. Other member countries of the Council will shortly be following suit and in addition a number of countries throughout the world have changed or contemplate changing to Brussels pattern tariffs. It is essential that importers and import agents should obtain copies of the new tariff as soon as possible, says the Board of Trade, otherwise they might encounter 'considerable' difficulties in clearing their goods through the ports as it incorporates a large number of amendments and additions.

BSI yields to pressure

Industry's comments and criticisms on the provisional (1949) edition of British Standard 1500, which dealt with fusion welded pressure vessels for use in the chemical, petroleum and allied industries, have been taken into account in a new publication revising the sections dealing with carbon and low alloy steel pressure vessels. Complaints that they were handicapped in the export trade because the design stresses imposed by BS 1500 were too severe have been voiced by manufacturers. The BSI now says it is very alive to the need to lower factors of safety but that this cannot be achieved without adequate data. Action is being taken to obtain it 'with a view to taking further steps as soon as possible'. The foreword to the 133-page illustrated publication states: 'the design of pressure vessels, particularly in the chemical industry, is the subject of continuous development, and it is intended to keep the standard under review in order to incorporate such modifications as are found desirable as a result of progress'.

£M1 equipment ordered for NIRNS

Electrical equipment valued at almost £M1 is now being built by the English Electric and British Brown Boveri companies for the 7000 MeV proton synchrotron under construction at the Rutherford High Energy Laboratory, Harwell. The contracts were awarded by the AEA who hope to have the machine ready for the National Institute for Research in Nuclear Science in about eighteen months' time. The order covers a £500,000 converter plant (Brown Boveri) and £470,000 rotating machinery (English Electric).

Purpose of the equipment is to supply accurately regulated pulses of power to the windings of the eight sections of the synchrotron's 7000 ton ring-shaped electromagnet, to keep the protons in their path as they are accelerated. 35 megajoules of energy has to be converted from stored energy in flywheels to field energy in the magnet at a controlled rate during three-quarters of a second while the protons are being accelerated, then returned to the flywheels for about a second until the next pulse. The 380 tons of rotating machinery will consist principally of two large motor-alternator-flywheel sets mechanically coupled together. Power fed in by the motors to keep the process going is 10,000 hp. The converter plant includes excitrons—large mercury vapour switches—timing and control equipment, and transformers. Brown Boveri of Switzerland have designed similar equipment for the large proton synchrotron under construction for the European Nuclear Research Centre (CERN) at Geneva.

Transistors only for US breeder

Instrumentation and safety systems for the 100 MWe fast breeder reactor of the US Enrico Fermi Atomic Power Plant are to employ transistors and other solid-state devices exclusively. The contract was recently awarded by the constructors — the non-profit making Power

Reactor Development Company—to the Bailey Meter Co of Cleveland, Ohio, who subcontracted it to the Stromberg-Carlson division of General Dynamics Corporation. The reactor will be completed late in 1960 and delivery of the instrumentation is due in February of that year.

The safety system will monitor the neutron flux and its rate of change, and also pressures, temperatures, and coolant flow rates. It will be designed to work over a range from 10^{-10}% to as high as 700% of the reactor's rated power capacity. Neutron detectors will feed straight into solid state computing modules and the system is to include self-monitoring equipment which will test every circuit for quantitative as well as qualitative data and provide an arrangement to detect and locate circuit failures. The techniques have been under development in Stromberg-Carlson's Research and Advanced Development Division for more than two years; they are similar to transistorized instrumentation apparatus recently delivered by the company to the Knolls Atomic Power Laboratory for the prototype naval nuclear reactor.

SWISS SCIENTISTS VISIT UK Dr H. Alberts (left) and P. Moses (right) from Reaktor AG and Dr Denis Taylor, director and general manager of Plessey Nucleonics and Nuclear Power's Instrumentation Consultant Editor, discuss a component of the burst slug detection equipment which Plesseys have supplied to Reaktor AG for the Zürich water-cooled reactor

New cable cooling trebles current

The first electric cable in the world to be internally water-cooled has been manufactured by Siemens Edison Swan Ltd and installed on the 450 MeV synchrotron at Glasgow University. Similar cable is to be used by the AEA in ZETA. Both installations have been engineered in conjunction with Metropolitan-Vickers Electrical Co. The idea of the internal water-cooling technique is to achieve much greater current carrying capacity for the same overall diameter cable. In the Glasgow installation the cable, which is in the form of a coil, is designed to cater for 3000 amp plus about 1500 amp in pulses. Uncooled it could carry only about 850 amp. The voltage involved is 8–10 kV and water flow about 10 ft/min. Overall diameter is 1·7 in., and 7000 ft of the cable is coiled in two annular plastic trays. The advantages of water over oil as a cooling medium include the avoidance of gaps, as the water—itself a semi-conductor—adheres closely to the conductor. The water is, moreover, not necessarily re-circulated, and no special pumping facilities are needed. In its present form the cable build-up consists of a stranded copper duct insulated with extruded polythene and reinforced with two layers of terylene braid.

Power-Gas takes over A. C. Wilson's

Mr A. C. Wilson, founder of A. C. Wilson and Partners Ltd, engineering consultants of Ealing, has sold his interest in the company to the Power-Gas Corporation Ltd. In the last few years Wilson's have carried out several contracts for the UKAEA including: Dounreay — underwater fuel element handling facility, experimental loops for materials testing reactor, equipment for hot cave facility, highly active waste disposal; Windscale—equipment for irradiated fuel laboratory; Springfields—fuel element heat treatment plant; Harwell—experimental reactor test rigs.

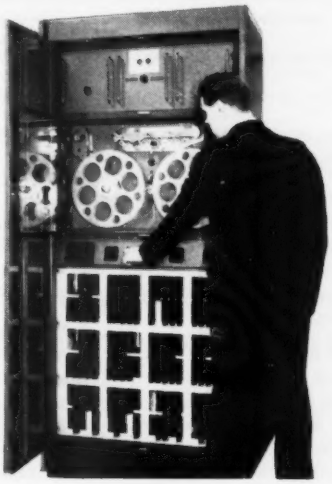
Data system for Harwell

A transistorized data recording and analysing system has been developed by EMI Electronics in conjunction with Atomic Energy Authority scientists and engineers, to assist in handling the quantities of statistical data required from Harwell investigations. It will meet the need for continuous monitoring of nuclear experiments for periods up to 24 hours, and is designed to measure to accuracies of 0·1% or less.

The system is made up of a number of self-contained recording units and a central high-speed analyser. The recording units, located near the experimental rig, take the measured quantities—for example, the neutron time of flight, and scintillation counter identity—and convert them into binary coded digital form. The coded data at a typical resolution of 0·2%, is then recorded on magnetic tape in parallel form using 16 channels on 1 in. wide tape. At the end of the recording run, the tapes are removed from the recording units for high speed processing on the central analyser. This handles the tapes at speeds of up to 100 in. a second, and the digital information is read off the tape at high speed and automatically sorted into ordered array on a ferrite core store. It can then be transferred on to punched paper tape for further processing by a digital computer; alternatively punched card or graphical output can be provided.

Plug-in construction has been employed to make as much use as possible of EMI's range of 'bricks'. Many of the units in the Harwell system, for instance, are identical with those used in the company's latest digital com-

PORT FOR HINKLEY OPENED MV 'Sea Tern' from Glasgow arrives with the first 240 tons of equipment to be unloaded at the newly completed dock at Combwich. Rebuilt by the English Electric-Babcock & Wilcox-Taylor Woodrow Group the port will be used to transport about 30,000 tons of plant to the 500 MW nuclear power station during the next two years



This transistorized data recording and analysing system is now watching over Harwell experiments for anything up to 24 hours at a stretch

puter, Emidec 2400. It was delivered to Harwell recently and is now being applied to its first job—neutron spectrometry measurements.

Nuclear Chemical heads named

The men who are to run the new firm Nuclear Chemical Plant Ltd, which was formed jointly by The Power-Gas Corporation, Humphreys and Glasgow, and John Thompson (*Newsdesk* October) are: Chairman—R. W. Rutherford, joint deputy managing director of The Power-Gas Corporation. Directors—C. Gresle Farthing, deputy chairman and joint managing director of Humphreys and Glasgow, and J. H. N. Thompson, deputy chairman and joint managing director of John Thompson. C. J. Carter, a director of John Thompson-Kennicott, C. Robson, a director of the Power-Gas Corporation, and N. H. Williams, a director of Humphreys and Glasgow, are appointed alternate directors.

Mr J. Jowitt (Humphreys and Glasgow) is appointed as general manager and E. J. G. Good (The Power-Gas Corporation) as secretary. Headquarters have been established at 22 Carlisle Place, London SW1. The company will design and engineer process and treatment plant for the nuclear industry. Members of the staff who are being trained by the Atomic Energy Authority at the Risley Industrial Group are J. S. M. Jones (Humphreys and Glasgow), E. G. Spalding (John Thompson) and N. E. Williams (The Power-Gas Corporation).

BIRMINGHAM'S FIRST Starpiece of the new £150,000 foundry extension at Spartan Steel and Alloys Ltd, this Birlec 3-ton electric arc furnace is the first of its kind to cast stainless steel ingots in Birmingham, where only non-ferrous metals were produced in the past. The company was formed 16 months ago and is now making a variety of stainless steel alloys, including low carbon stabilized with titanium and niobium

IN BRIEF

● **Harwell steel** After obtaining ten orders in the last six months for work at Harwell, Hill & Smith Ltd have been appointed by the AEA as structural steelwork contractors at Harwell for the next two years.

● **Boron plan** The Dow Chemical Co and United States Borax Research Corp are to pool past research and engage in a joint venture to perfect an economic process for the manufacture of boron trichloride, a highly reactive intermediate from which many of the newer boron compounds can be made.

● **US grants for training** The AEC has approved 30 grants totalling $326,510 to 30 American colleges and universities for assistance in equipping their laboratories for training in nuclear technology as related to the life sciences.

● **Floating factory** A new factory of 16,000 sq ft is now being erected for Rocol Ltd at Swillington, near Leeds. Because of coal workings under the Rocol site, it is expected that the land will subside about two feet during the next five years, so the new building will be divided into six separate sections joined together with watertight expansion joints. Each section will thus be able to move separately without serious fracture.

● **Poles talk isotopes** Applications of radioisotopes in industry were discussed during a recent visit of three scientists from the Institute of Nuclear Research in Warsaw to Isotope Developments.

● **Siemens Edison Swan reorganize** As part of the long-term reorganization of the AEI Group, Siemens Edison Swan are to be divided into three divisions—cables, telecommunications and radio and electronic components—from Jan 1.

● **Metal Industries** The two biggest companies in the Metal Industries Group, Brookhirst Switchgear of Chester and Igranic Electric of Bedford, have joined forces in a new company—Brookhirst Igranic Ltd. Sir Charles Westlake (chairman of Metal Industries) is chairman; other members of the board are John Black (deputy chairman), H. Owen Houchen (managing director), J. O. Knowles and W. Padley.

● **Transistor show** The International Convention on transistors and associated semiconductor devices which is being arranged by the Radio and Telecommunication Section of the Institution of Electrical Engineers will be held at Earls Court, London, on May 21–27. The concurrent international exhibition will cover manufacturing, application, research and development aspects.

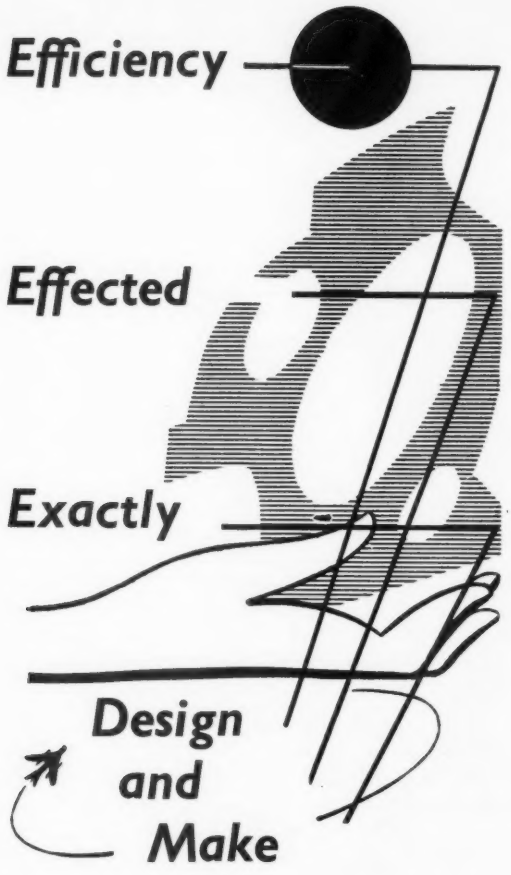
● **Birlec-Efco (Melting) Ltd** The top men of this newly formed company have been announced. Board consists of: George P. Tinker (chairman), J. C. Howard (managing director), F. S. Leigh (assistant managing director), D. L. Campbell, J. H. Crossley, P. F. Hancock, J. A. Monks and T. G. Tanner. The secretary of the company will be J. C. Mantell. Address is Westgate, Aldridge, Staffs. (*tel:* Aldridge 52071).

● **Fuel elements** International symposium on nuclear fuel elements sponsored by Columbia University and the Sylvania-Corning Nuclear Corporation will be held at the University on Jan 28–29.

● **Manipulator for Windscale** The Atomic Energy Division of The General Electric Co has received an order for its new power-operated manipulator (full description *May, p 237*) from the Industrial Group of the United Kingdom Atomic Energy Authority. This manipulator will form part of the expanding 'hot laboratory' facilities at the Authority's Windscale establishment, where its primary use will be in the inspection of irradiated fuel elements including, eventually, those from the commercial power stations at present under construction.

● **Grants for research** Several fellowships will be awarded to science graduates for research at continental Universities or Institutions during the 1959–60 academic year by the CIBA Fellowship Trust, CIBA (ARL) Ltd, Duxford, Cambridge. Details: the Secretary. Closing date Jan 31.

● **Design talks** The Bulleid Memorial lectures during February at Manchester University on 'Some modern developments in Engineering Design' will include one on nuclear power plant components. Details: Department of Mechanical Engineering.



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CATALOGUES AND BULLETINS

British Welding Research Association have undertaken to translate and issue to their subscribers monthly copies of the Russian publication entitled Automatic Welding, the official journal of the Arc Welding Institute of the Order of the Red Banner of Labour at Kiev.
Tick **No 201** on reply card

Leaflet 281057 from Cape Asbestos details concisely and clearly their Caposite heat insulating material.
Tick **No 202** on reply card

Specification sheet of the AEW range of electric muffle furnaces is now available.
Tick **No 203** on reply card

Technical booklet on controlled atmospheres for metallurgical processes by I. L. S. Golding has been issued by The Incandescent Heat Co Ltd.
Tick **No 204** on reply card

Brochure on the Ferranti Perseus data-processing system describes its applications in, for instance, an insurance office. Ferranti have also produced a classified index of computer literature.
Tick **No 205** on reply card

Large version of the Neumo pump made by Kingsbourne Products and described in our September 1957 number is on the market and literature is available.
Tick **No 206** on reply card

Fifteen years of semiconducting materials and transistors is the title of an excellent bibliography of published literature on the industry prepared and issued by Newmarket Transistor Co Ltd.
Tick **No 207** on reply card

Price list of welding and cutting equipment manufactured by D. S. Baddeley Engineering Co Ltd, plentifully illustrated with photographs, is available free from the manufacturers.
Tick **No 208** on reply card

Recent issue of Short Brothers & Harland's Computer News includes a description of a time delay unit designed for nuclear power and jet engine control problems.
Tick **No 209** on reply card

Yield determination by use of radioisotopes is the subject of the first of a new series of bulletins on the use of radioisotopes in routine chemical analysis brought out by America's Nuclear-Chicago Corporation.
Tick **No 210** on reply card

Brochure entitled neutron counters for reactor control from 20th Century Electronics includes descriptions of fast neutron counters and ionization chambers.
Tick **No 211** on reply card

Leaflet from Wallace & Tiernan Ltd describes the many applications of their work in the field of precision control in chemical feeding.
Tick **No 212** on reply card

Electrical and electronic testing instruments in the Avo Meter range are given full technical descriptions in a booklet from Avo Ltd.
Tick **No 213** on reply card

First edition of Technical Abstracts, a bibliography of technical articles compiled by the Lead Development Association has come out. It will be issued quarterly and companies and individuals will be placed on the mailing list free of charge on request to the Association.
Tick **No 214** on reply card

Interesting chart on the corrosive resistance of epoxy resins is included in booklet from The Staveley Iron & Chemical Co Ltd, who manufacture epoxy resin lined cast iron piping which has been satisfactorily tested at Harwell.
Tick **No 215** on reply card

New edition of Rocol Molybdenised Lubricants, No 3d has been published. The company say they have produced 28 specialized lubricants based on molybdenum disulphide in the last ten years.
Tick **No 216** on reply card

Publication from Pollard Bearings Ltd tabulates their complete range of *Maxload* bearings and ineludes relevant dimensions, weights, working load ratings and reference numbers for corresponding American made bearings.
Tick **No 217** on reply card

British Welding Research Association have brought out a book (H3/58) showing how to identify defects in aluminium fusion welds which can be seen in radiographs. Defects are classified, their origin explained and preventive measures suggested.
Tick **No 218** on reply card

Wire wound heat exchanger tubes in the 'Clayton Still' range made by Clayton Dewandre are illustrated and described in free brochure now available.
Tick **No 219** on reply card

JANUARY DIARY

ICE Institution of Civil Engineers. IMechE Institution of Mechanical Engineers. IEE Institution of Electrical Engineers. IChemE Institution of Chemical Engineers. IP Institute of Physics. PS Physical Society. SCI Society of Chemical Industry. IM Institute of Metals. IMet Institution of Metallurgists. IMM Institution of Mining and Metallurgy. IPE Incorporated Plant Engineers. SIT Society of Instrument Technology. BritIRE British Institution of Radio Engineers. RSH Royal Society of Health. IR Institute of Refrigeration.

FRIDAY 2
FAWLEY SIT Instrumentation of the Dounreay reactor *K. R. Sandiford* Copthorne House

TUESDAY 6
EDINBURGH IEE Electrical installation at Calder Hall nuclear power station *N. J. Mackay, E. Hardwick* 7.00 Carlton Hotel, North Bridge

WEDNESDAY 7
MIDDLESBROUGH IEE ZETA—the engineering aspects of the British controlled thermonuclear reaction experiments *R. Carruthers* 6.30 Cleveland Scientific and Technical Institute, Corporation Rd

WEDNESDAY 14
NEWCASTLE BritIRE The design and construction of an electronic digital computer *R. W. Walker* 6.00 Institution of Mining and Mechanical Engineers, Nevill Hall, Westgate Rd

LONDON SIT Symposium on storage media *D. F. Nettell, E. J. Petherick, M. E. Theis, D. W. Willis* 6.00 Manson House, Portland Place, W1

LONDON IP Controlled thermonuclear reactions *Sir George Thomson* 5.30 Lecture Theatre of the Royal Institution, 21 Albemarle St, W1 Admission by ticket

THURSDAY 15
LONDON IEE (with BNEC) Electrical installation at Calder Hall nuclear power station *N. J. Mackay, E. Hardwick* 5.30 at the Institution

MONDAY 19
CARDIFF IEE The future pattern of nuclear electricity power stations *I. Everson* 6.00 South Wales Institute of Engineers

LONDON PS 43rd Physical Society Exhibition Royal Horticultural Old and New Halls. Ends January 22

TUESDAY 20
CHESTER ICE Separation of isotopes by molecular distillation *P. T. Nettley* 7.00 The Blossoms Hotel

MANCHESTER IEE The atomic clock *L. Essen* 6.15 Engineers' Club, Albert Sq

THURSDAY 22
SHEFFIELD IEE Informal lecture *Sir Christopher Hinton* 6.30 at the Grand Hotel

TUESDAY 27
LONDON SIT Symposium on flow measurement. *R. E. Fischbacher, P. Scanes, B. W. Balls, F. R. Allen* 6.00 Manson House, Portland Place, W1

THURSDAY 29
BRISTOL BritIRE Recent developments in printed and potted circuits *H. G. Manfield* 7.00 School of Management Studies, Unity St

nucleol

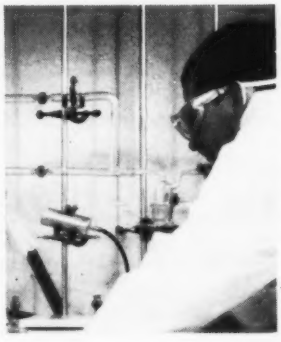
radiation resistant lubricants for the atomic age

A range developed and perfected by Wakefield-Dick Research

Conventional oils cannot live in conditions of atomic radiation. Such conditions are inseparable from certain parts of any mechanism designed to produce power from nuclear fission.

This, and other allied lubrication problems, was the challenge which faced oil technologists everywhere. And, as so often in the past, Wakefield-Dick's research team produced the answer. An entirely new series of oils and greases, resistant to radiation and named "Nucleol", is now available to lubricate the wheels of this Atomic Age.

INDUSTRIAL WAKEFIELD-DICK LUBRICANTS



A Wakefield-Dick research chemist investigating the effects of radiation on lubricants.

Two examples of the NUCLEOL range

NUCLEOL 522 A radiation resistant lubricant based on selected mineral oils of high aromaticity and containing special inhibitors.

NUCLEOL G 114 A grease gelled with a new compound, and specially inhibited. Designed for the lubrication of control actuator bearings operating at the lower radiation levels.

FROM OUR BOOK LIST:

Die radioaktiven Elemente.
by Professor Dr. S. J. Bresler.

Translated from Russian. Size: approx. 6″×8¼″, 346 pp., 87 illustr., 35 tables. Imitation leather, DM 27—

Die technischen Anwendungen der Radioaktivität,
by Professor Dr. Engelbert Broda and Dr. Thomas Schönfeld.

2nd (revised) edition. Size: approx. 6″×8¼″, 324 pp., 25 illustr. Imitation leather, DM 19—
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Leitfaden für Radioaktivität und Strahlenschutz,
by B. G. Gussev.

Translated from Russian. Size: approx. 6″×8¼″, 138 pp., many plates. Imitation leather, DM 14—

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by Hans Hart and Ewald Karstens

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Radioaktive Isotope in der Metallurgie,
by I. S. Kulikov and I. A. Popov.

Translated from Russian. Size: approx. 6″×8¼″, 256 pp., 120 illustr., 34 plates Imitation leather, DM 21—

Prüfung metallischer Werkstoffe mit Gammastrahlen,
by S. W. Rumjanzev and J. A. Grigorovitsh.

Translated from Russian. Size: approx. 6″×8¼″, 284 pp., 172 illustr., 34 plates Imitation leather, DM 17—

Verschleißuntersuchungen mit Hilfe radioaktiver Isotope,
by P. J. Diatshenko et al.

Translated from Russian. Size: approx. 6″×8¼″, 132 pp., 82 illustr., 16 plates. Imitation leather, DM 11.20

This book will enable many readers to become acquainted with the results of research and experiments carried out by Russian research workers who examined the wear and tear of machinery by means of radioactive isotopes. The main advantage of the method is that the part to be examined can be tested while the machine is in operation, i.e., under normal service conditions, so that specific conditions of wear and tear are automatically indicated and the progress of work can be adjusted and controlled.

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Book Reviews

The authority

The Neutrino J. S. Allen. London 1958: Oxford University Press. 36s

The continuous energy distribution of the electrons emitted by beta radioactive emitters, by J. Chadwick (1914) and others, had led to an irritating dilemma: the experimental results were either incorrect, which was extremely unlikely, or the basic law of physics of the conservation of energy did not hold for elementary processes, but only on the average. The situation was saved by W. Pauli (1933) who postulated that with every beta particle emitted a second neutral particle was ejected from the nucleus: it was christened the 'neutrino'. Owing to its lightness (mass ~ 0) and absence of charge it remained hypothetical until 1956 when C. L. Cowan, F. Reines, F. B. Harrison, H. W. Kruse and A. D. McGuire observed it and with the help of neutrinos emitted from the Savannah River reactor established the inverse of the usual decay process: neutrino + proton = positive electron + neutron. Previous to this the main method of studying the neutrino, and, at the same time, the physical basis of the beta decay, consisted in investigating the angular correlation between electron and neutrino through the coincident observation of the direction of the heavy nucleus recoil and electron.

This and many other aspects of the neutrino are dealt with in the present volume written by Professor James S. Allen. The author has been doing research in this field for more than 10 years and is considered the authority in this field of experimental physics. This monograph is and will remain *the* authoritative account of the neutrino, though some modification will have to be included later to record the effects of the recently discovered violation of parity in weak interaction processes such as beta decay. As far as possible the implications of this new discovery of immense importance have been added as postscripts to the chapters where the situation has changed. The content of the book covers roughly: general properties of the neutrino, its rest mass neutrino recoils following orbital electron capture, electron-neutrino angular correlation, double beta decay, detection of free neutrinos, meson neutrino reactions and the general Fermi interaction. Dr Allen's book is well written and a pleasure to read. There are few misprints (see page 5 'special' instead of 'spatial' inversion). Print and illustration are good.

E. Bretscher

Practical flavour

Accelerators of Ions and Electrons Cestmír Simáne. London 1958: Constable. 16s.

It is unfortunate that the English translation of this book on the design and operation of particle accelerators arrives so late, only two references being as recent as 1952. Inevitably in so important a field of research progress over the past few years has been extensive and in certain aspects revolutionary. Most accelerators built since the above date use the principle of strong focusing in some form or other and a treatment of this subject would form an essential part of any modern book on accelerating machines.

With this limitation the book is of restricted use to those working on accelerator research and development and its greatest value will be to those engaged in the operation and maintenance of existing machines and to the practically-minded student.

After a general review of the subject and a short section on vacuum problems the author deals in detail with the two main classes of accelerator, linear and circular. Many photographs of machines in each category are reproduced and special design features receive attention both in the text and illustrations. Most of the theory is reserved for the appendices with the result that the main text acquires a very practical flavour. The short chapter headed 'Conclusion' might well have been omitted.

M. Snowden

For designers

Compact Heat Exchangers W. M. Kays and A. L. London. New York 1958: McGraw-Hill 156 pp 4s 6d

The results of systematic experiments and analysis of work on compact heat transfer surfaces are summarized here under one cover. The book has much to commend it, the salient advantages being the mode of presentation of the results and, in particular, the adoption of a standard type of analysis and nomenclature for some 88 surface configurations. The impetus for the work

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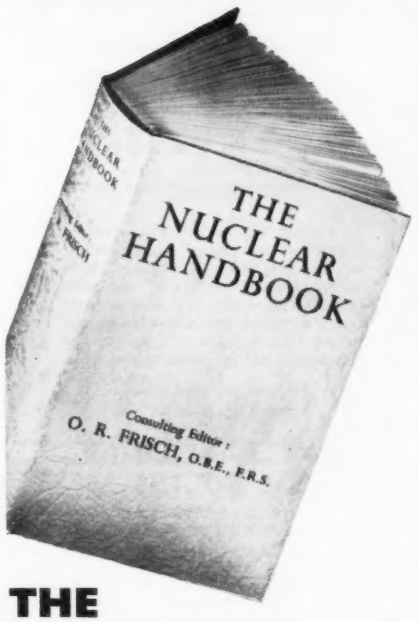

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covered was provided by the need for compact heat exchangers in gas turbine plant. However, the field of application is much wider and includes such branches as air-conditioning, aircraft cooling and even gas-cooled nuclear power reactors.

The analytical treatment departs from previously accepted methods in the use of the criterion NTU, a heat transfer parameter which depends on three basic design factors :

1. A, the total heat transfer area on one side of the exchanger,
2. U, the overall coefficient of heat transfer,
3. C_{min}, the minimum flow stream capacity rate, i.e. the product of $(M.C_p)_{min}$, where M is the mass flow and C_p is the specific heat at constant pressure.

The use of NTU and ε the heat transfer effectiveness, or thermal ratio as it is sometimes called, provides designers with two distinct advantages in their work. Firstly, the rearrangement of the basic thermodynamic relationships in terms of ε and NTU (as distinct from q and the log mean temperature difference) provides a clearer physical picture for designers to grasp the fundamental theoretical issues involved. Futhermore, the use of a log mean temperature difference is misleading in so far as it implies the use of one equation only, namely the q–log mean temperature difference equation. In fact, as this work shows, the energy equation is also involved, but the latter is 'hidden' in the q–log mean temperature relationship.

Where convenient, results are expressed in graphical form and the task of the designer is thus greatly simplified. Specimen calculations for four different configurations are given in one of the appendices.

Finally, in another appendix, a full mathematical treatment for some of the theory in the main text is included as a guide for design.

G. Boxer

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The Geneva Presentation Volumes 12 vols. Addison-Wesley Publishing Co Ltd, USA. London: Academic Books Ltd. Price £30 complete—individual volumes available.

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The Americans are really remarkable people. The authors of these books are all very well-known and presumably feverishly busy men yet they find time to sit down and produce these bang-up-to-date books without seeming effort (most of them were walking about at Geneva as if nothing had happened!). Also much of the information in the books is the sort of thing our 'commercial security' people would stamp on, hoping presumably to sell it to someone or at least to keep it away from his competitors. Imagine for instance a 600-page book on gas-cooled graphite-moderated reactors by a leading British authority—I can't.

It should be pointed out that these Addison-Wesley volumes were published for the AEC and no mention is made anywhere of non-American activities—Amasa Bishop's brilliant one on fusion for example doesn't mention British or Russian efforts at all. This is however quite intentional: the object was to tell Geneva just what America had done up till now. It's not too late for Britain to do something like this, for we too have a good story to tell.

It is impossible in the space of one review to do more than give titles and authors of this series. They are:

Project Sherwood—the US programme in controlled fusion by Amasa S. Bishop

US research reactor operation and use by Joel W. Chastain jr

Radiation biology and medicine edited by Walter D. Claus

Uranium ore processing by J. W. Clegg and D. D. Foley

Thorium production technology by F. L. Cuthbert

Solid fuel reactors by J. R. Dietrich and W. H. Zinn

Physical metallurgy of uranium by A. N. Holden

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Fluid fuel reactors edited by J. A. Lane, H. G. MacPherson and F. Maslan

The transuranium elements by Glenn T. Seaborg

Sodium graphite reactors by Chauncey Starr and R. W. Dickinson

The Shippingport PWR by staff of AEC, Westinghouse and Duquesne

Throughout, the information is surprisingly fresh and there was little in the Geneva papers that is not here. Truly a remarkable piece of publishing and a great international act by the AEC.

C.D.

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NAMES IN THE NEWS

Prof A. D. Baxter, chief executive of the rocket division and the nuclear power group and **Mr W. F. Shaylor,** commercial manager of the de Havilland Engine Co Ltd have now been elected directors.

The board of Elliott Bros (London) Ltd has been joined by **Admiral Sir Ralph A. B. Edwards.**

Steels Engineering Products Ltd have appointed **Mr W. D. Cartwright** as field sales executive. He will be based on London. **Mr C. E. Drew** has been made an overseas sales executive.

Mr K. S. Phillips has taken up an appointment with Research & Control Instruments Ltd as sales controller. He was formerly with Siemens Edison Swan.

Manager of Barlow-Whitney's Neasden factory **Mr D. F. Ward** has now been made a director of the company.

America's Power Reactor Development Co have announced the appointment of **John G. Felders** as health physicist for the Enrico Fermi plant.

Fielden Electronics Ltd have appointed **Mr R. Speller, Mr F. G. Totty,** and **Mr F. B. Price** to be managers of their newly formed, London, North-east and Midlands divisions respectively.

New-year appointments are announced by Philips Electrical Ltd. **Mr H. Thorne** becomes personal assistant to the managing director, responsible for market development. He will be succeeded as general regional manager, South-east region by **Mr W. F. Cassidy.** The post of regional manager, Midlands region vacated by Mr Cassidy will be taken over by **Mr D. E. Beard.**

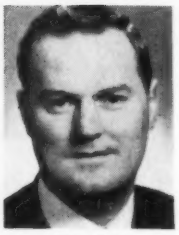
Two new appointments have been made by Wayne Kerr Laboratories Ltd. **Mr G. G. Gouriet** formerly head of the BBC's television research department has joined the board, and **Mr G. L. Ball** has been made general sales manager.

Ferranti's have appointed **Mr J. H. Thompson** to be a director.

Mr J. R. Thomas and **Comdr E. G. Sutton,** RN (retd) have been made directors of John Thompson (Wolverhampton) Ltd. The board of Ruston & Hornsby Ltd have elected **Mr V. R. Prehn** to be deputy managing director and **Mr E. R. Jones** and **Mr C. T. Alderson** will be assistant managing directors.

Carbide Industries Ltd, a unit of the chemicals division of the British Oxygen Co have appointed **Mr R. A. Millar**

V. R. PREHN



G. L. BALL

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Craig to be general works manager of their new factory at Londonderry.

Sir Leslie Rowan and **R. P. H. Yapp** have been appointed to the board of Vickers Ltd.

OBITUARY

Mr A. S. Dodds, director and London manager of John Thompson Water Tube Boilers Ltd on November 4.

Mr E. J. Waddington, a director of Vickers Ltd and Vickers-Armstrongs Ltd on November 9.

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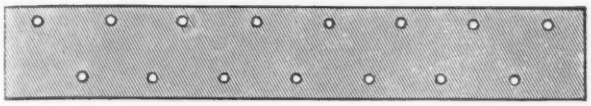

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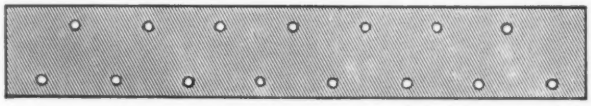

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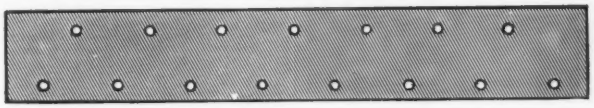

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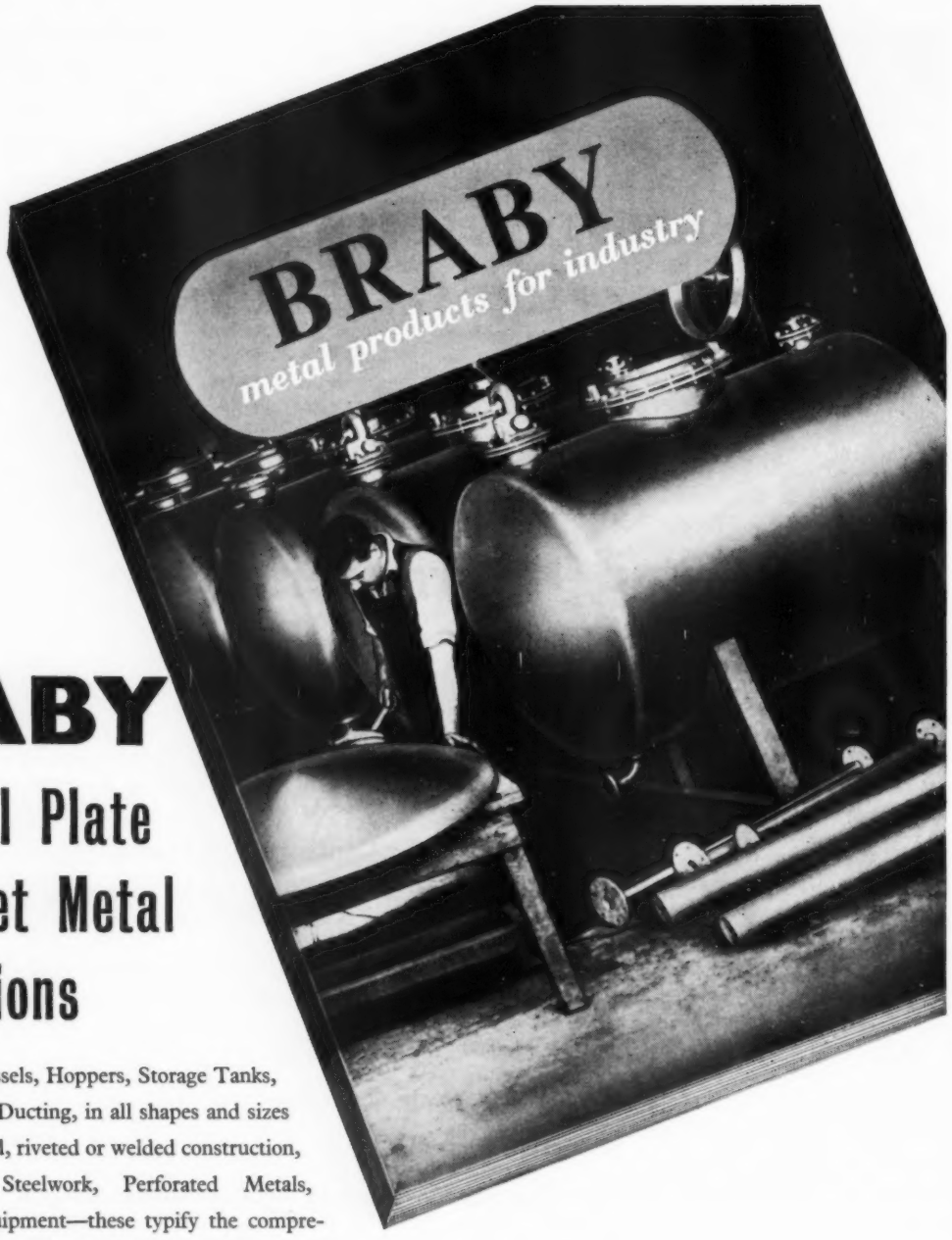

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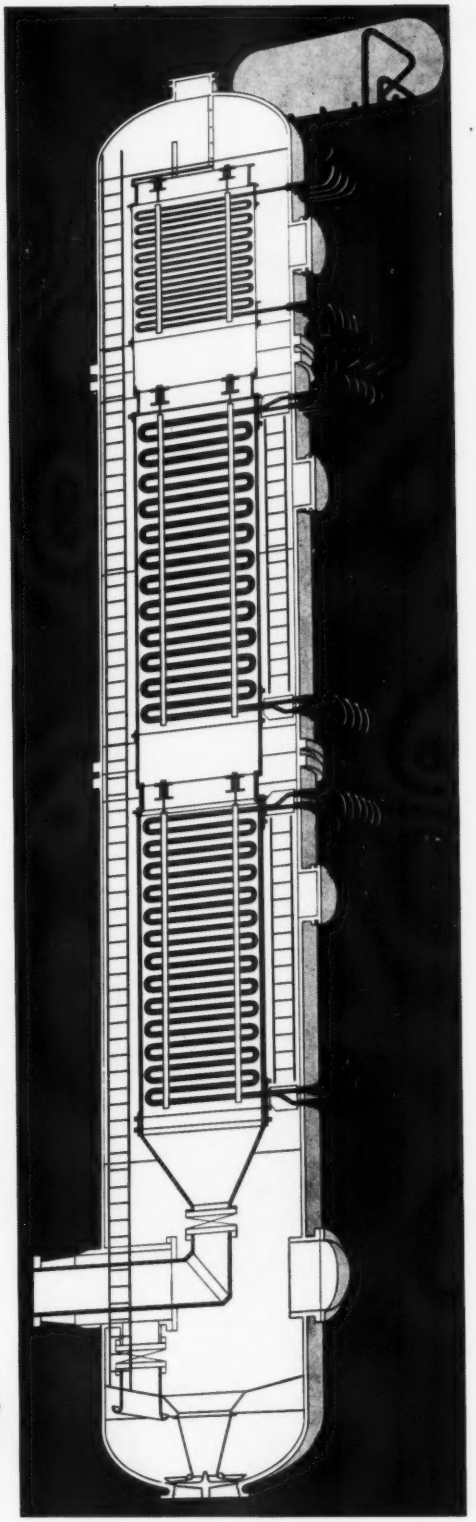

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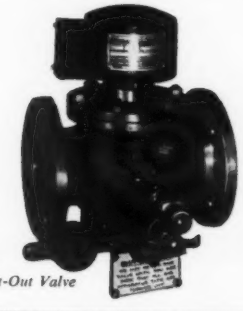

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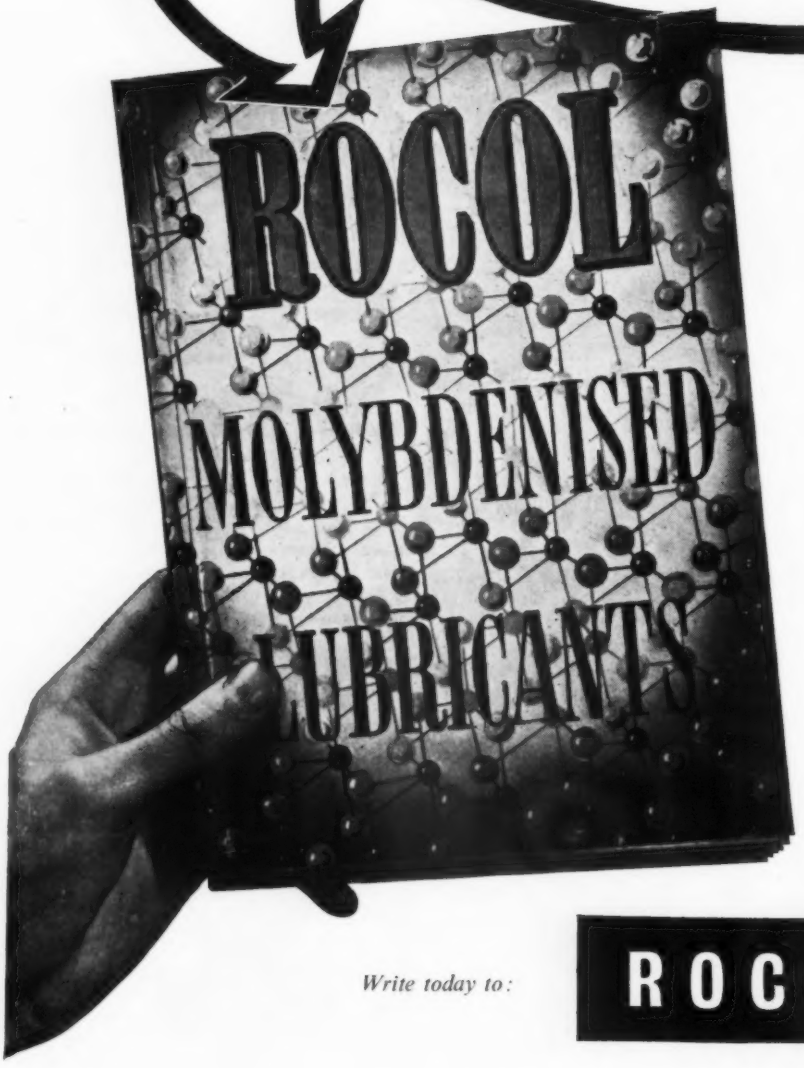

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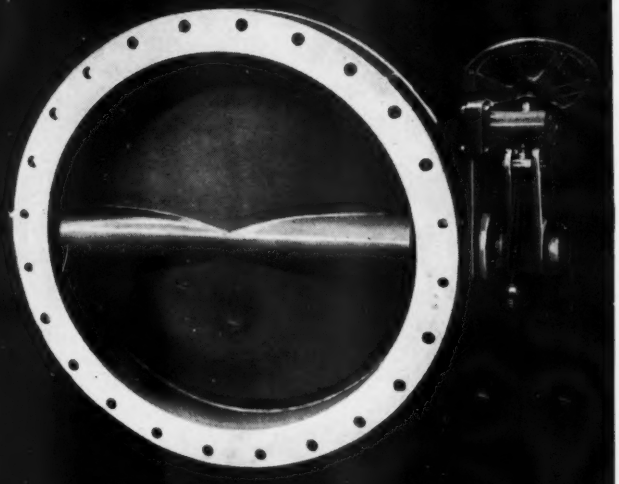
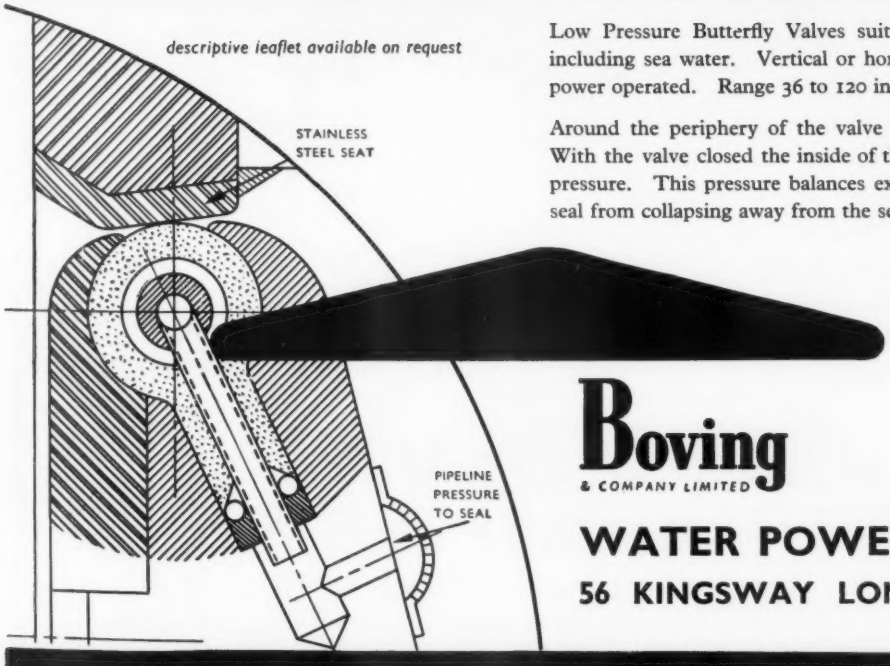


descriptive leaflet available on request



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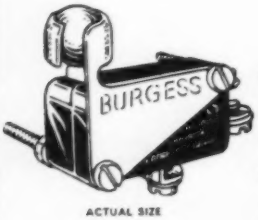

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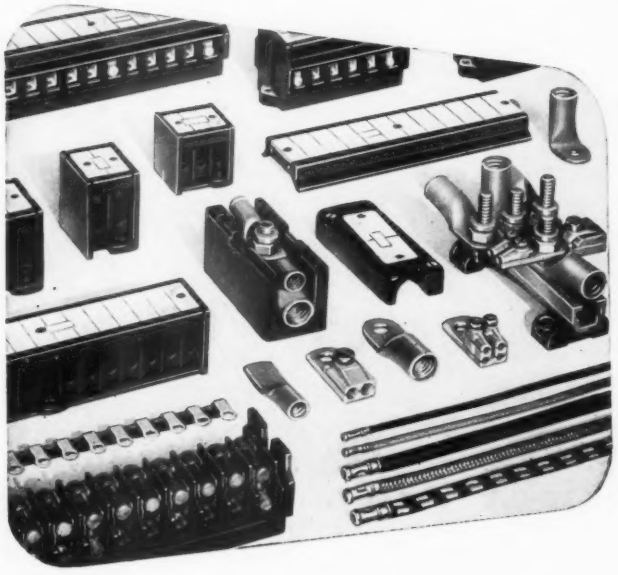

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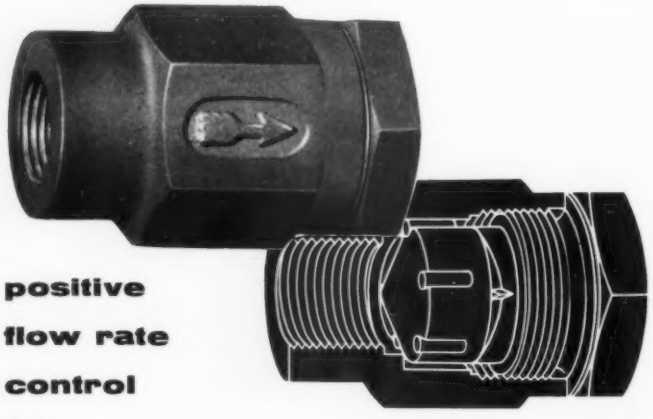

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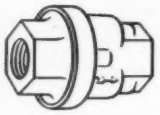

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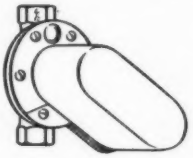

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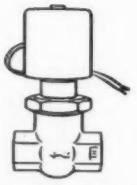
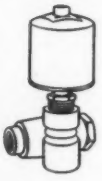
For positive flow-rate control with minimum (0·1 g.p.m.) or maximum (40g.p.m.) limits.



FLOMAX
A solenoid valve for maximum flow rates. Sizes up to 1¼" B.S.P.



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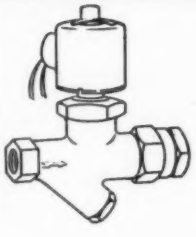

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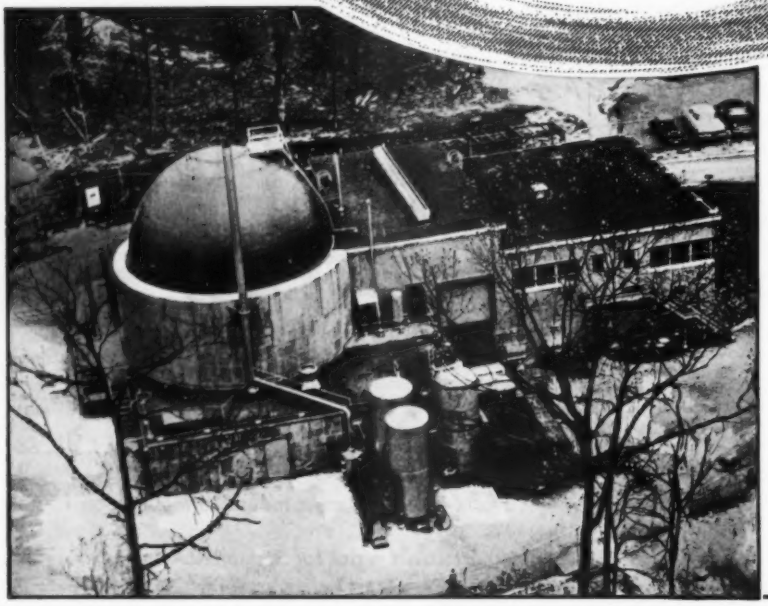

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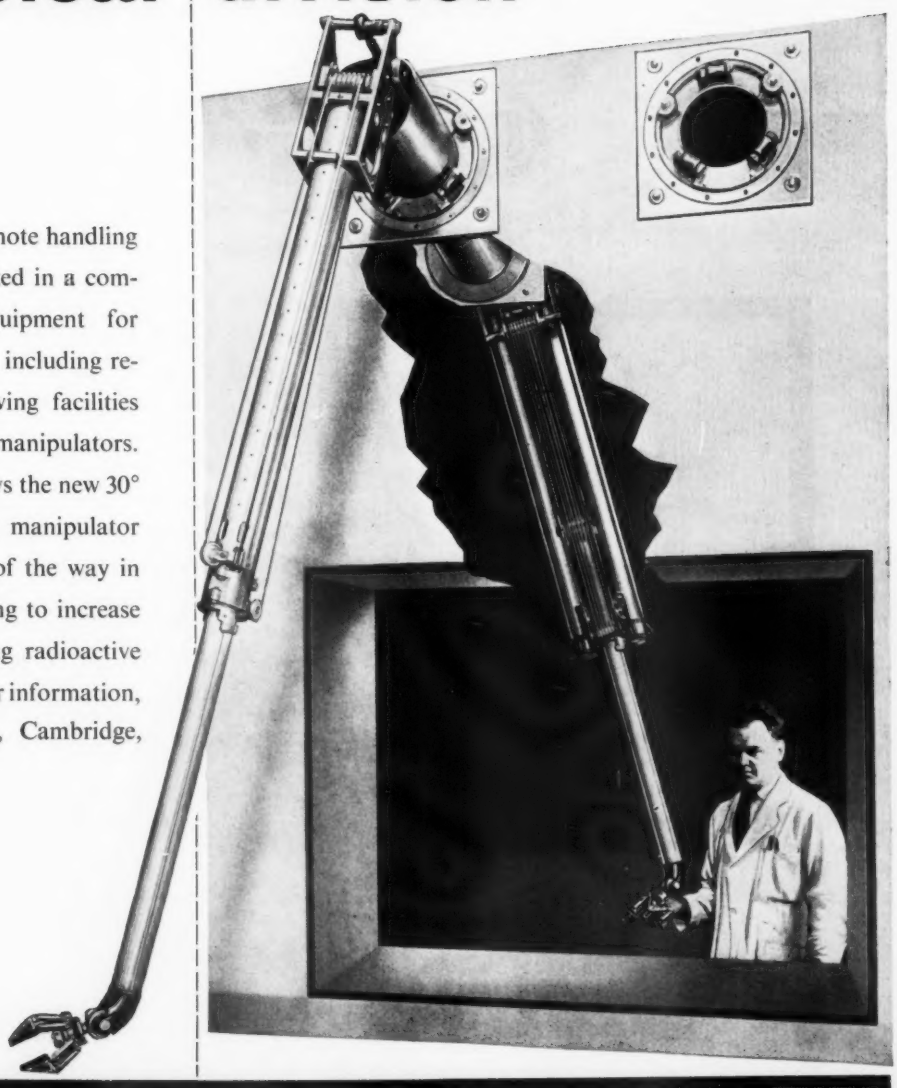

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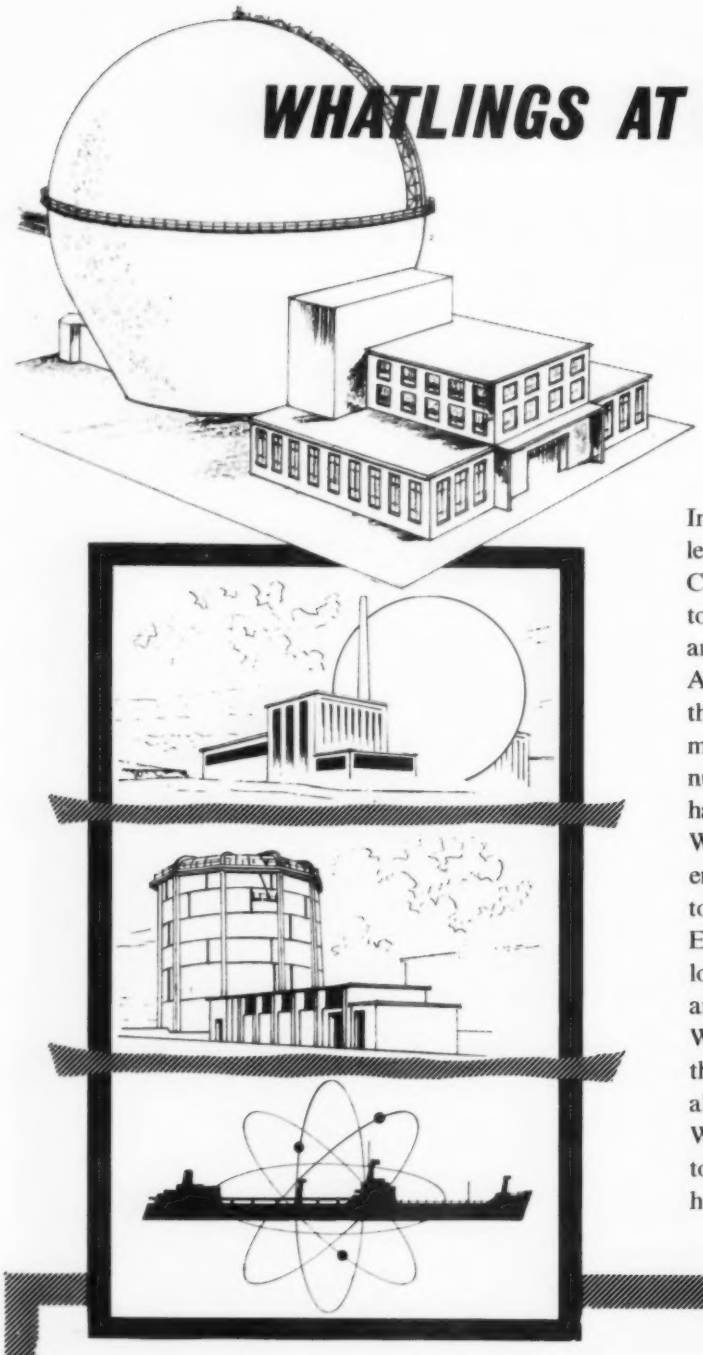

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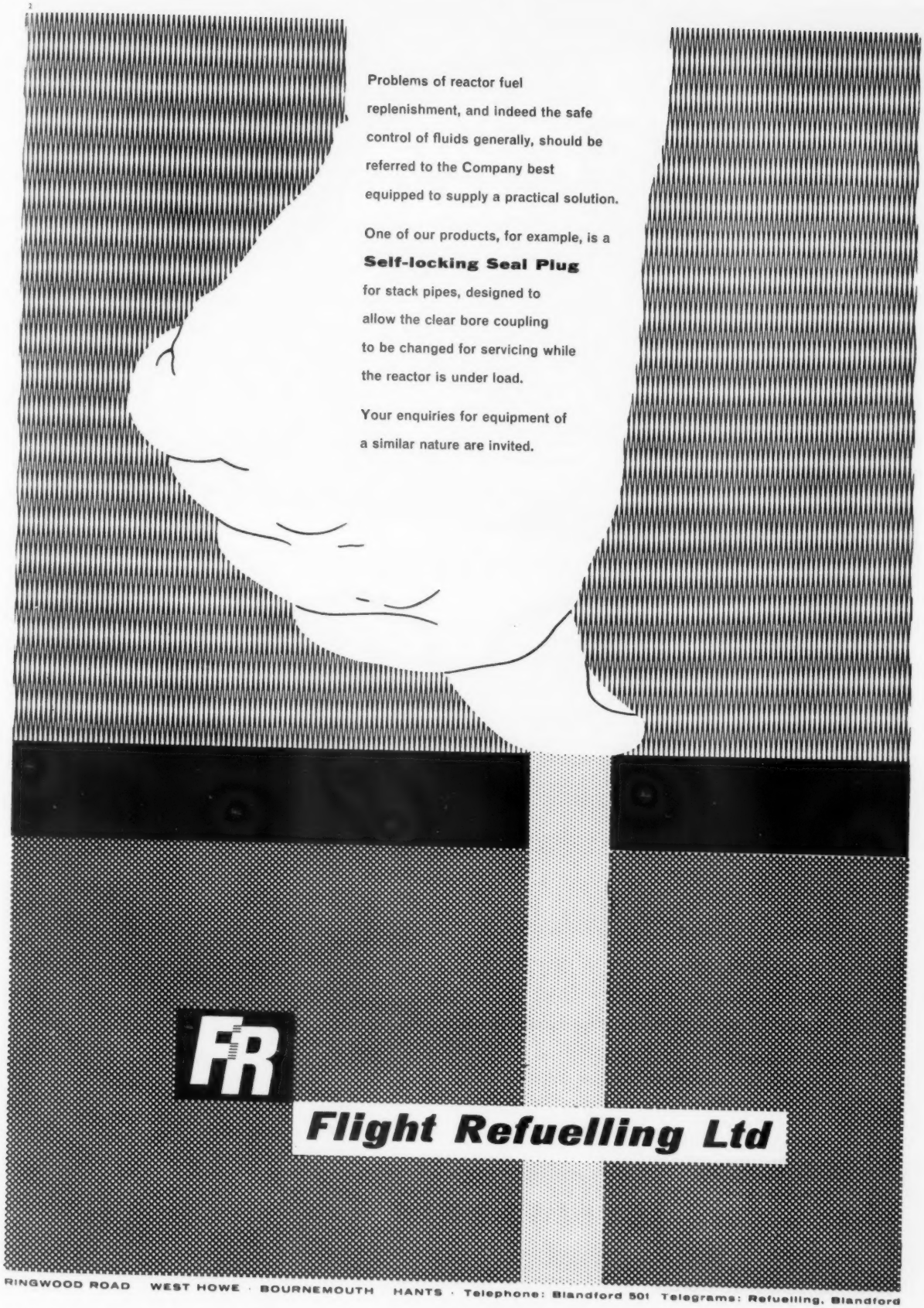
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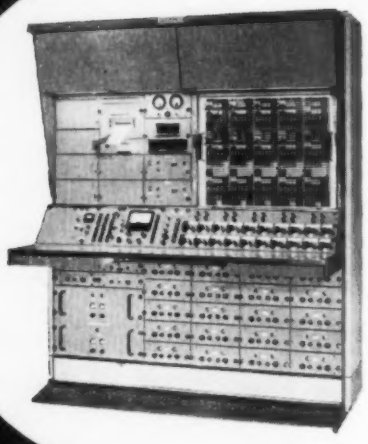

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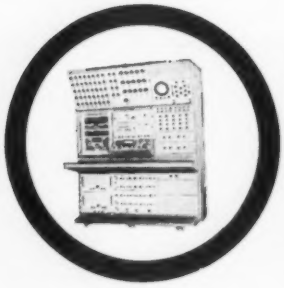
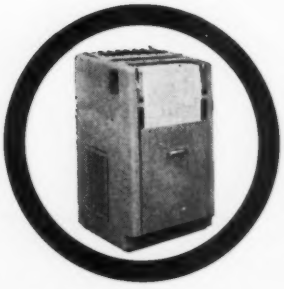


131 R Analog Computer



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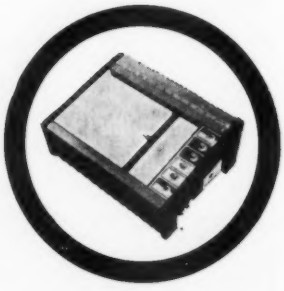

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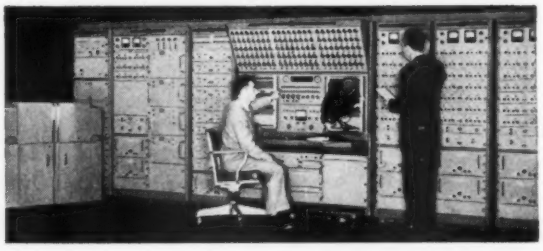

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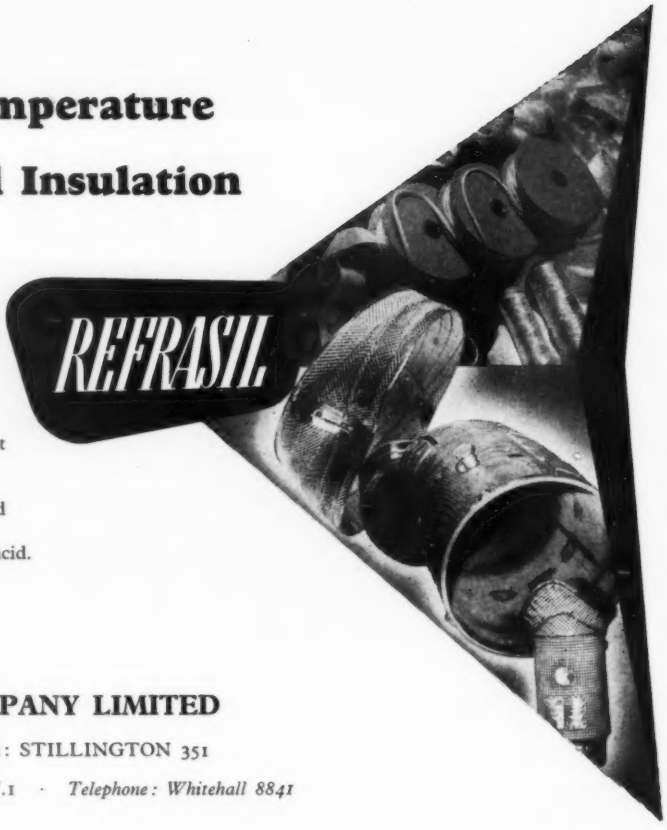

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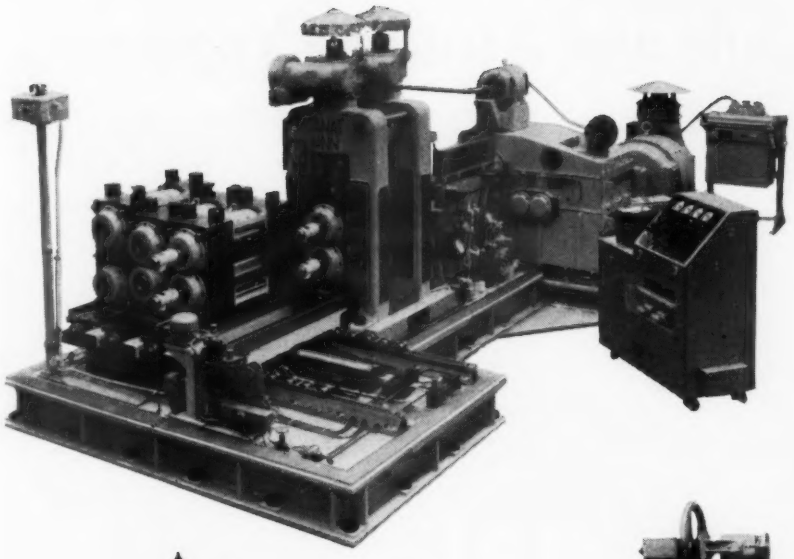

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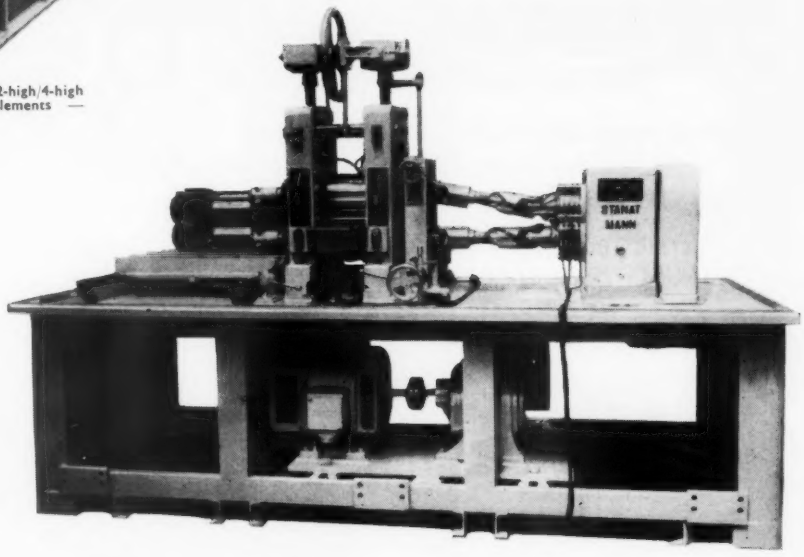

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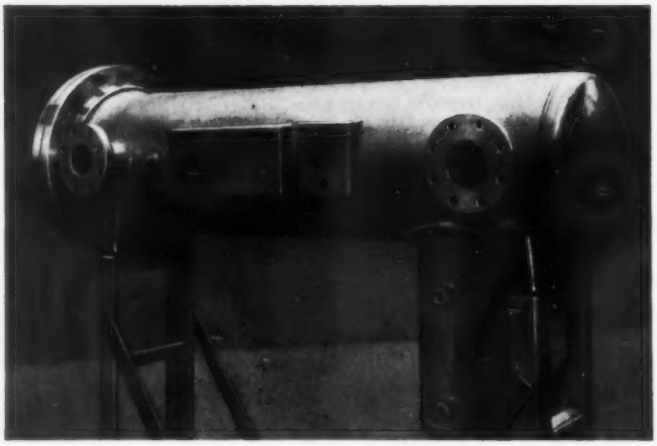

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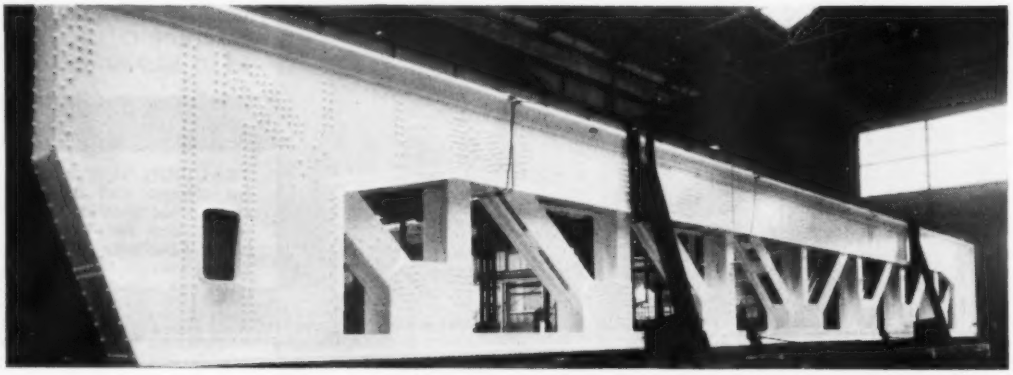

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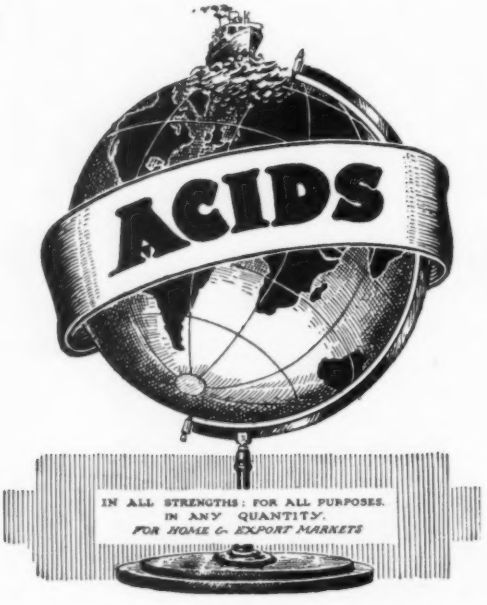

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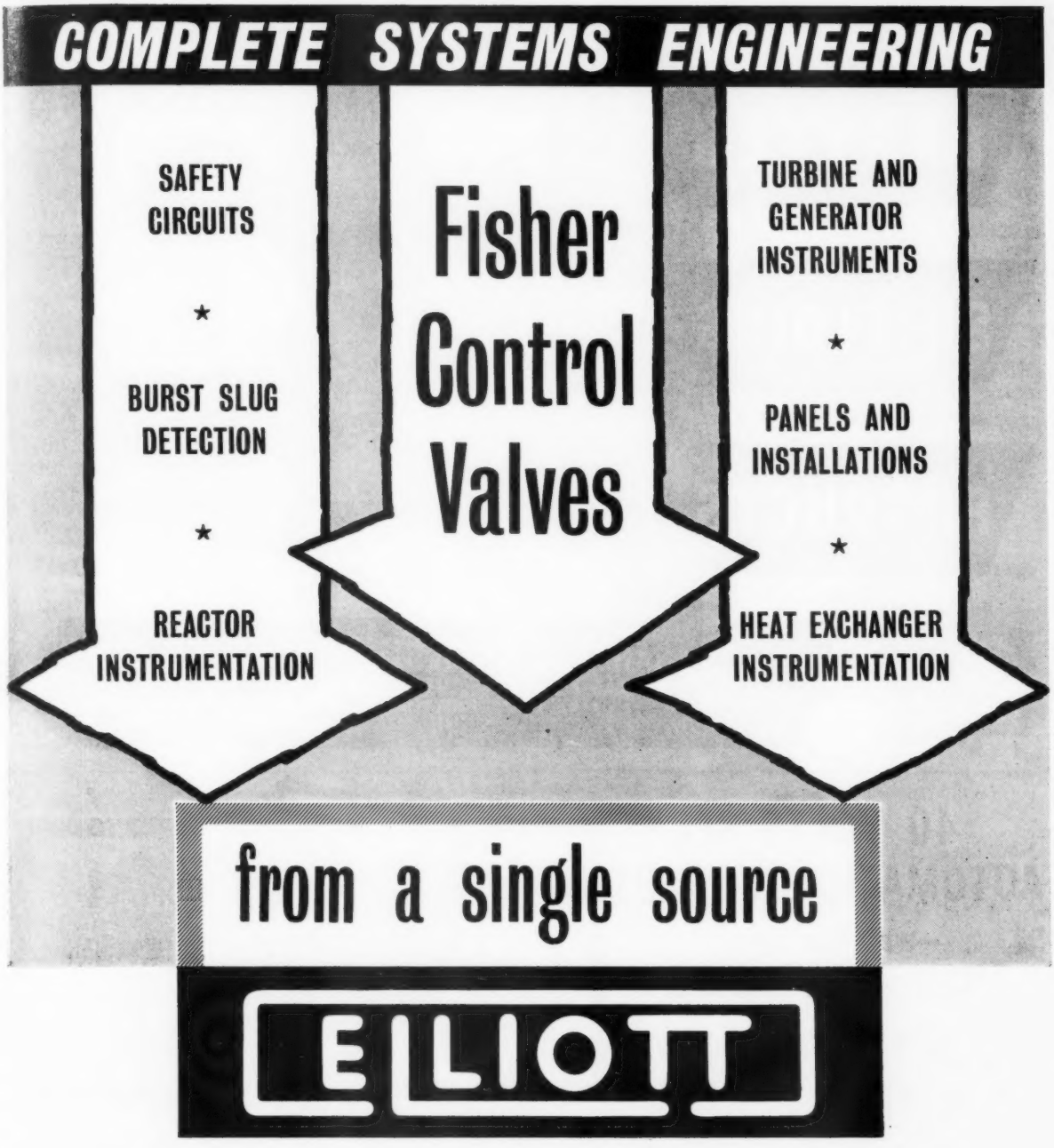

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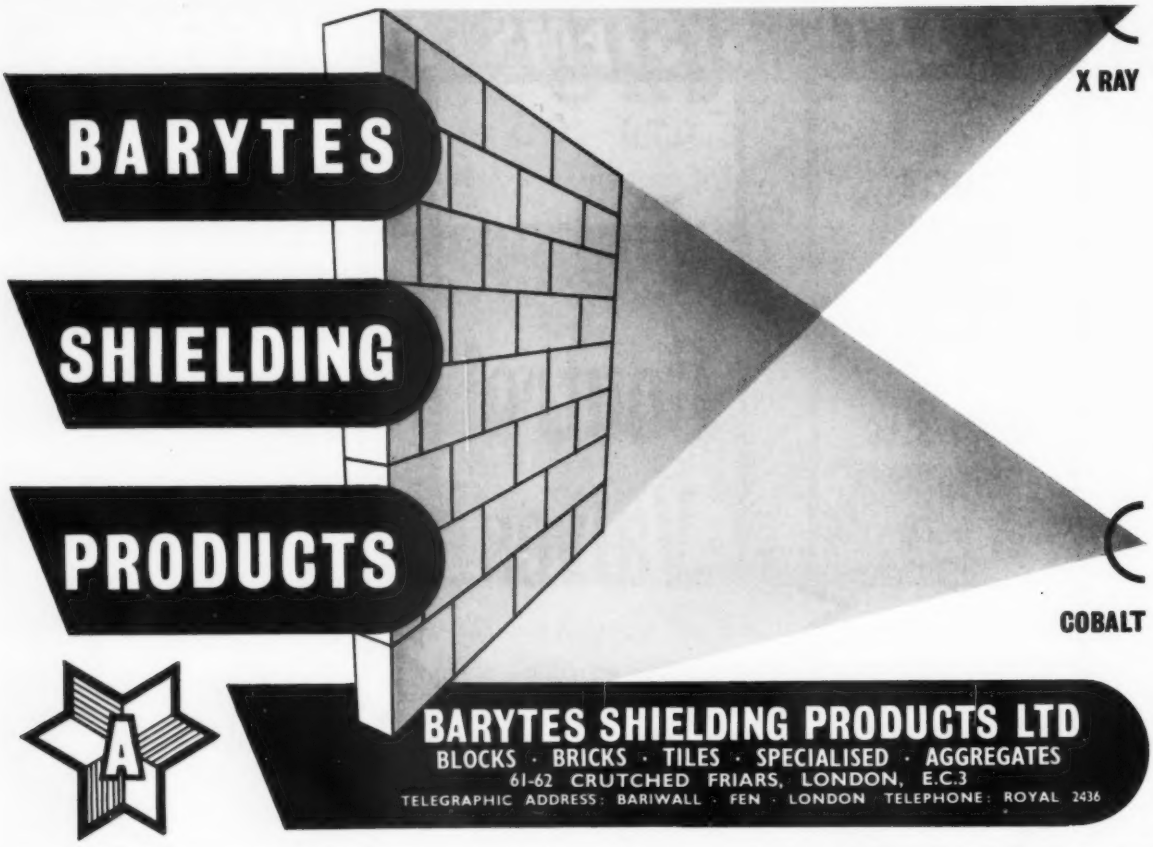

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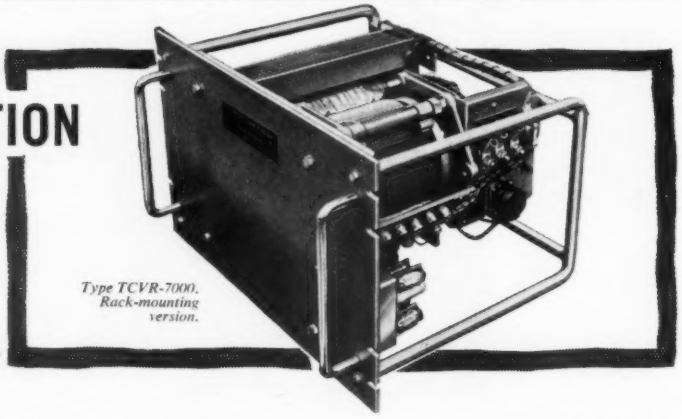

Type TCVR-7000. Rack-mounting version.

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for fluid measurement and control

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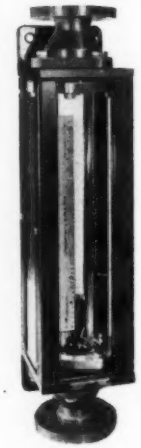

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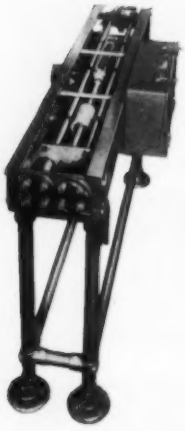

The density of piped flowing liquids, including slurries and corrosives, are continuously measured by the R.M. transmitting density meter. Density changes of the order of .002 gm/ml. can be readily detected, with choice of electric or pneumatic signal.

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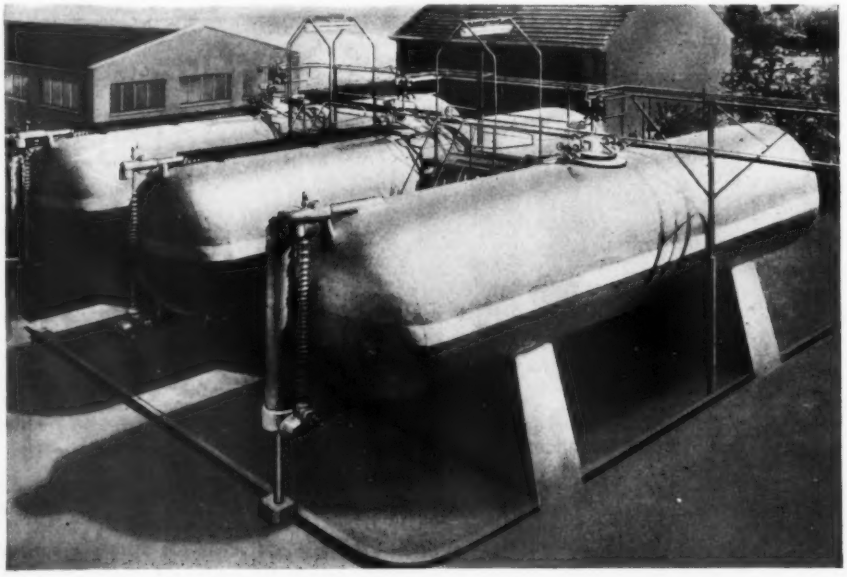

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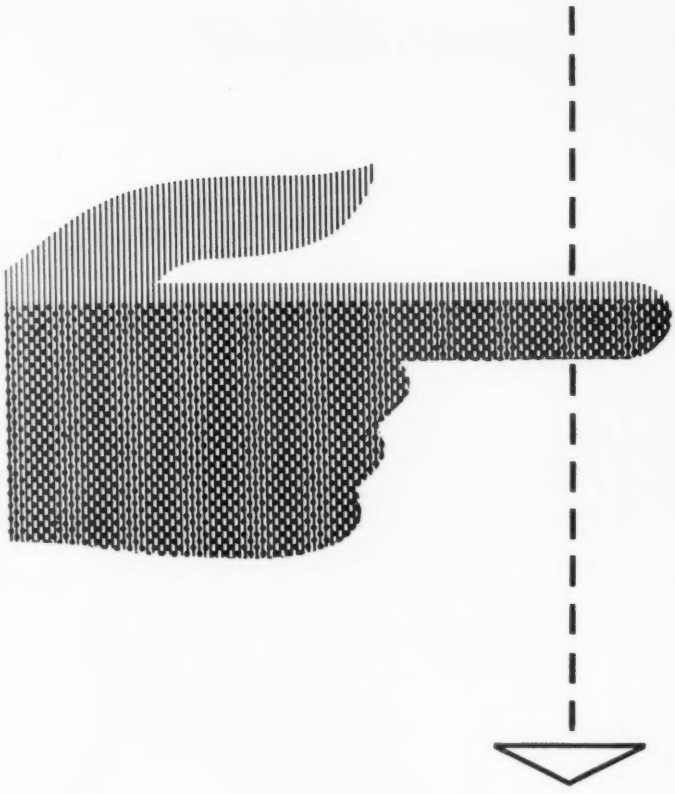

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As the size of gas-cooled reactors increases, use of computer technique for burst slug detection and display, in place of the earlier recorder methods, becomes essential. The many advantages of a computer technique are illustrated by equipment now being made by Sunvic Controls.

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An artist's impression of the gas activity monitoring display equipment being built for C.E.G.B. use at the Berkeley nuclear power station by Sunvic, who are also supplying instrumentation for the boilers and blowers.

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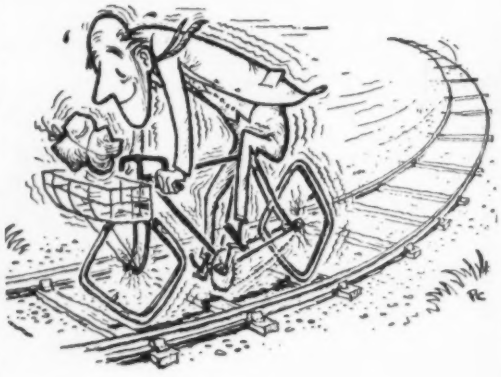

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This was the starting point

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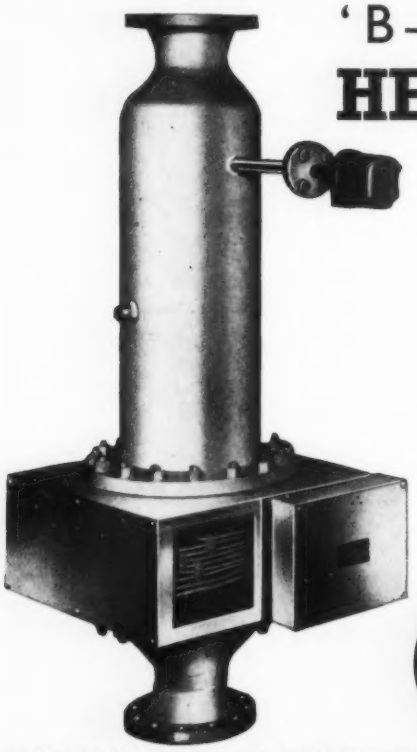

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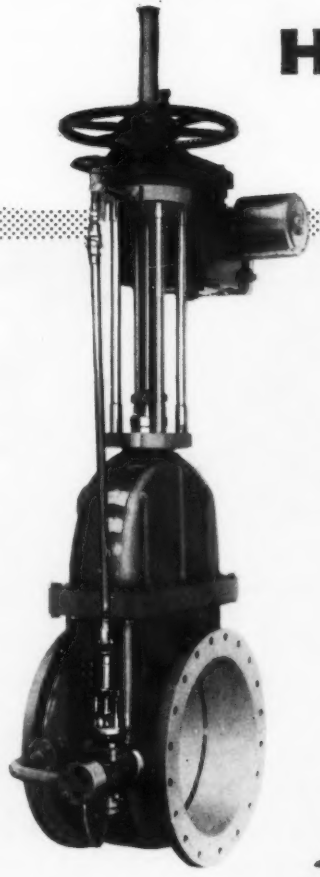

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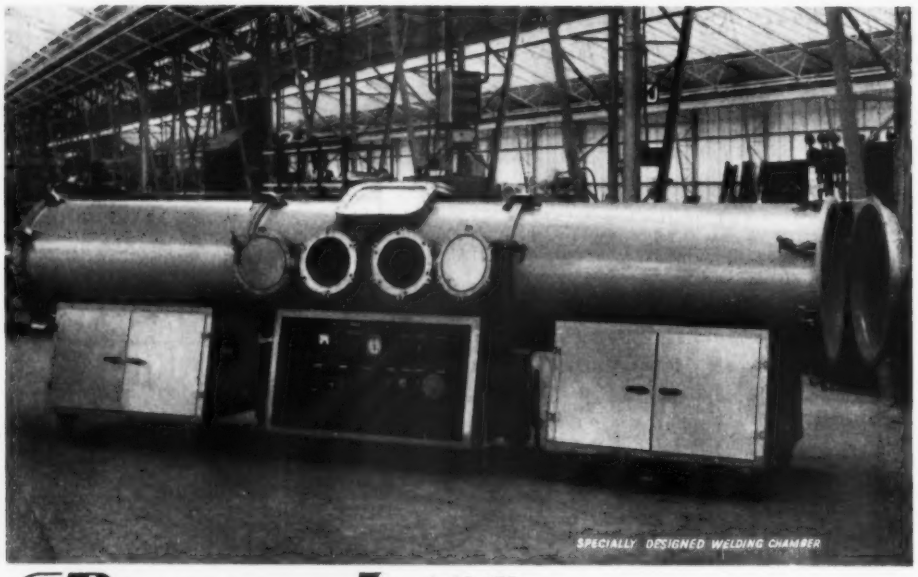

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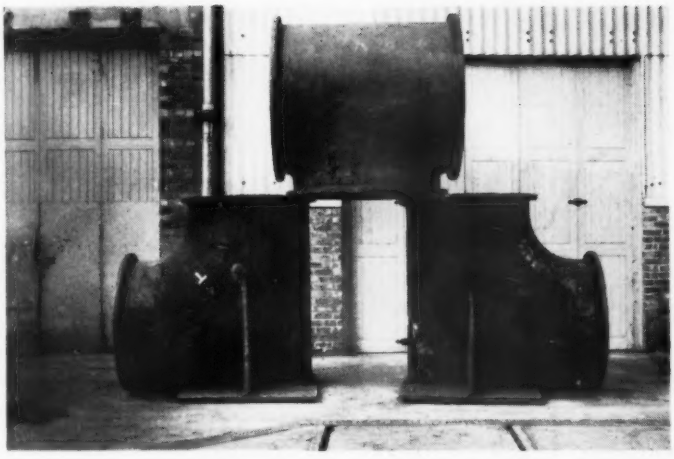

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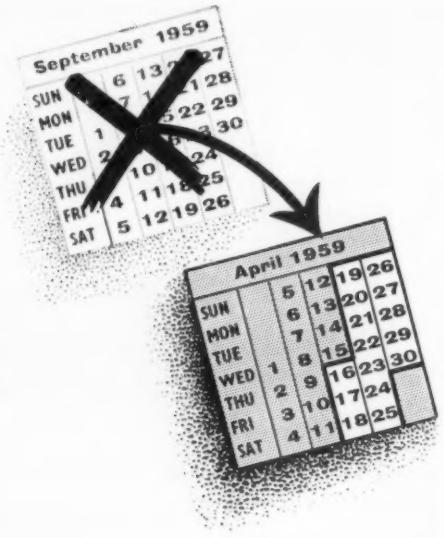

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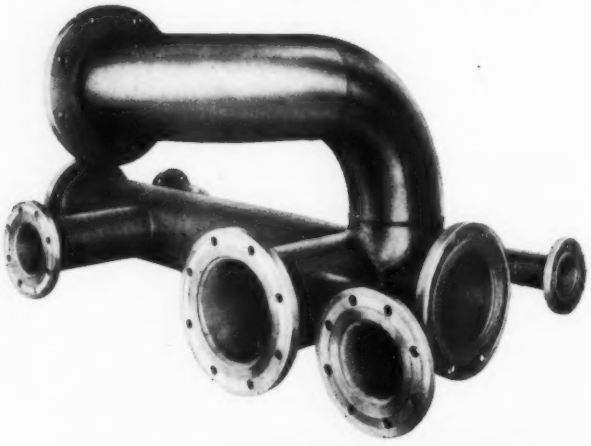

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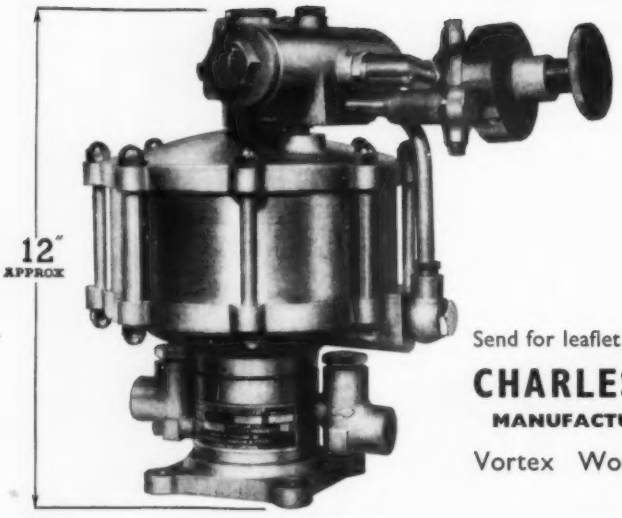

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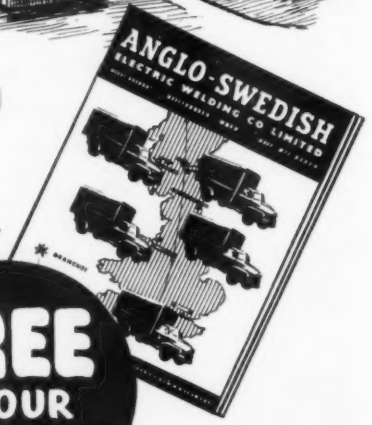

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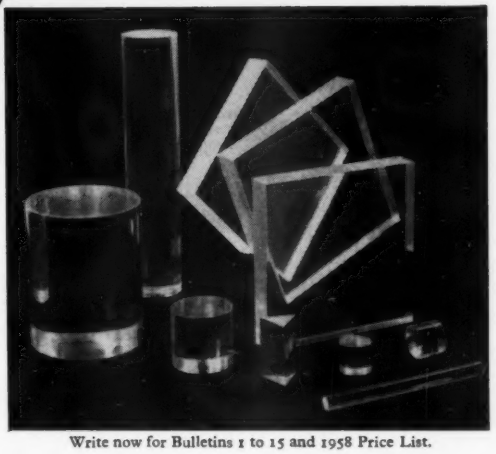

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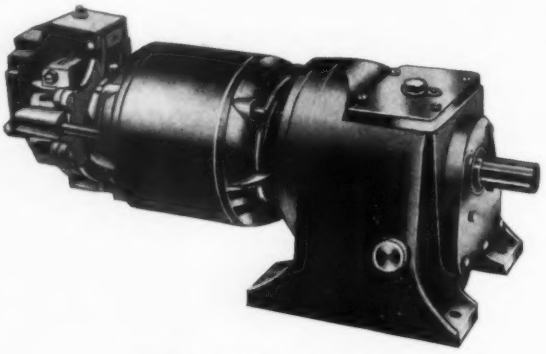

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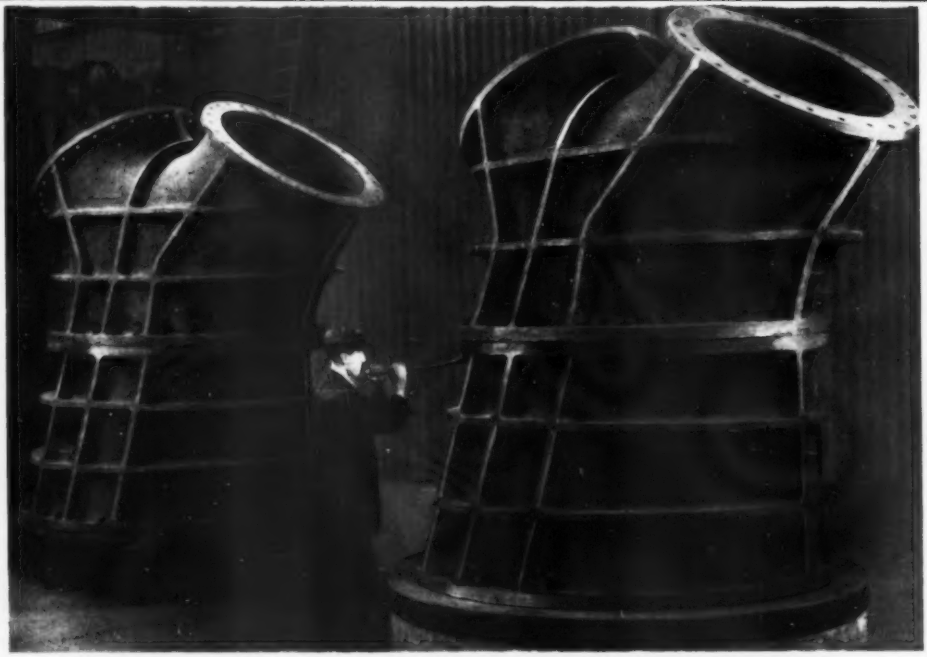

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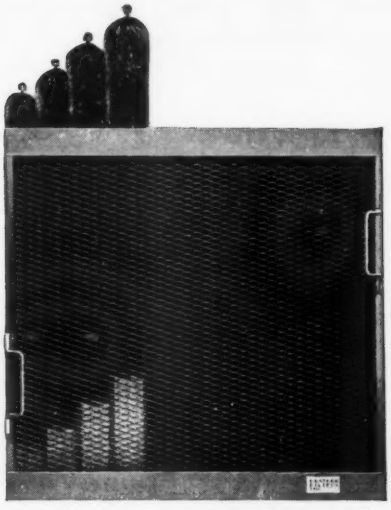

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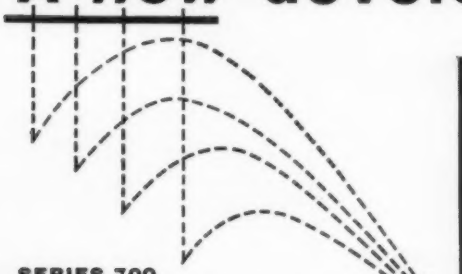

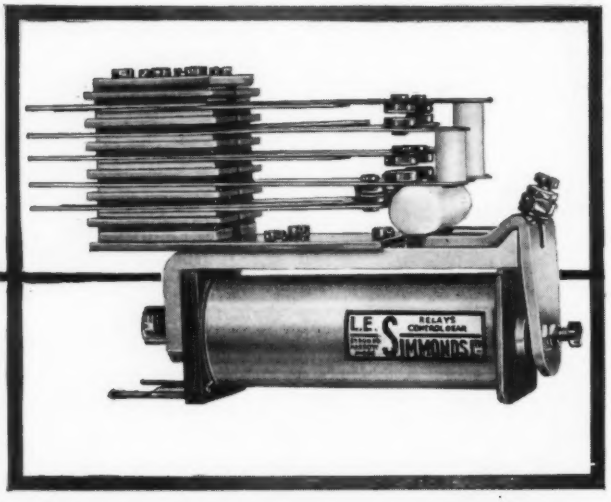

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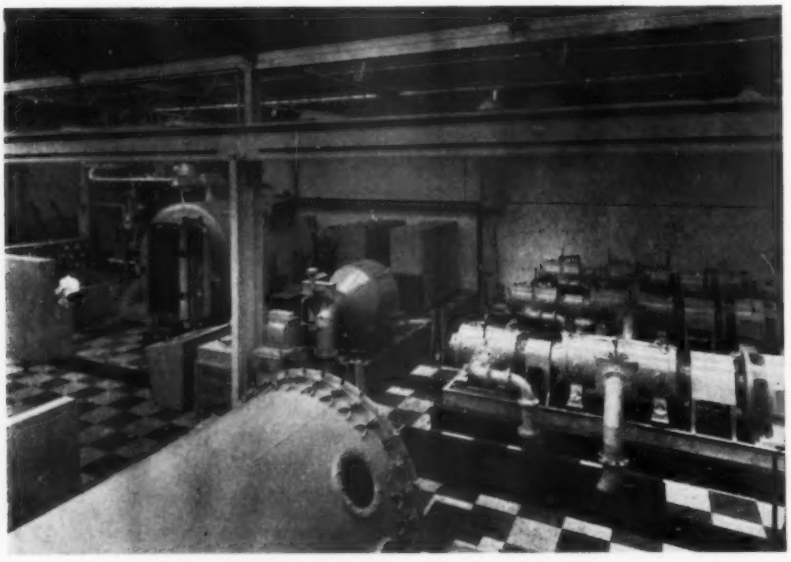

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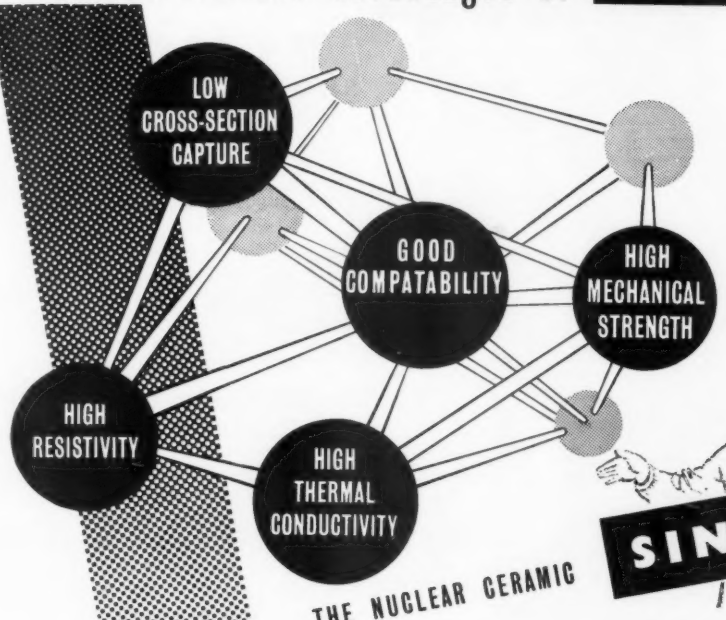

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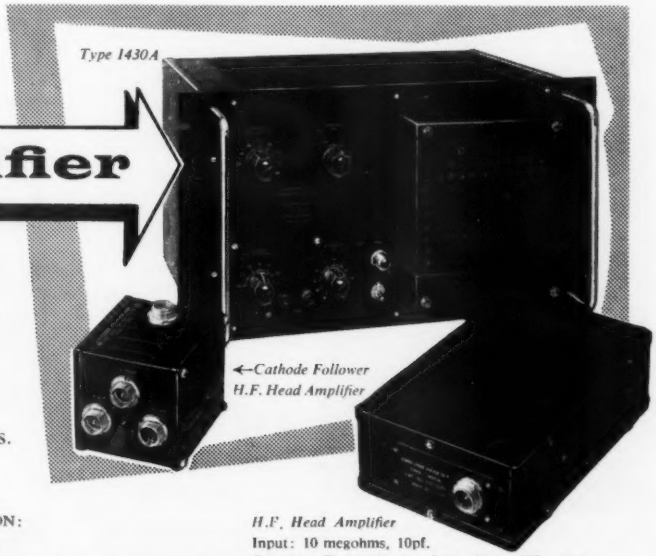
pulse amplifier



Pulse Amplifier, Type 1430A is a wide band linear amplifier comprising three units designed for use with fast ionisation chambers, proportional and scintillation counters.

SPECIFICATION:

Main Amplifier

Input: 100 ohms impedance. Negative polarity.
Gain: Maximum 86dB. Coarse Control: −0 to 20dB. Fine Control: −0 to 20dB in steps of 2dB each.
Integrating Time Constants: 0·08μs to 8μs in 7 steps.
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Saturation 70v.
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Input: 10 megohms, 10pf.
Output: Designed to feed into 100 ohm matched cable.
Gain: 31·5dB.
Filter: E.H.T. Filter suitable for voltages up to 3kV.

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Insertion Loss: 23dB.
Filter: As in H.F. Head Amplifier.

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Scalers · Pulse Generators · Pulse Analysers · Power Units · Probe Units · Pulse Amplifiers · Instrument Racks

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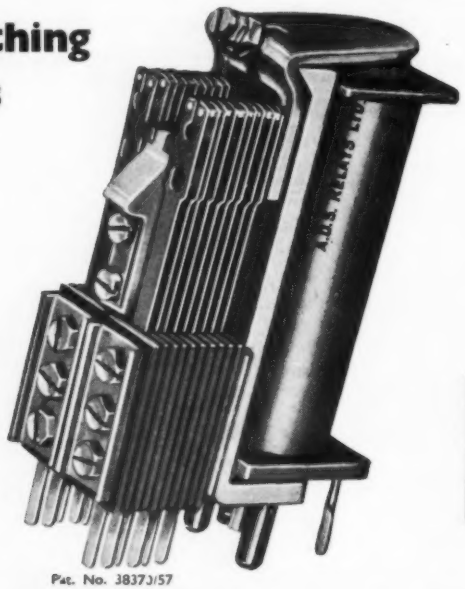
There's nothing new in this relay EXCEPT



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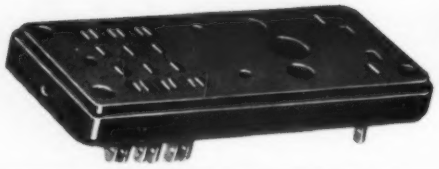

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The circuit embodies a UKAEA patent and employs a low-voltage, halogen-quenched tube in a simple integrator circuit that provides three ranges of visual response by flashing neon and a loudspeaker count of each ionizing event at low radiation together with an immediate appreciation of any significant flux change at higher intensities.

The Utility Counter is suitable for radioactive survey in the location of thorium or uranium ores and for realistic Civil Defence training. The pulse output socket facilitates connexion to external circuits, oscilloscope or recording scale and is thus of particular advantage for demonstrating nucleonics in schools and technical colleges.

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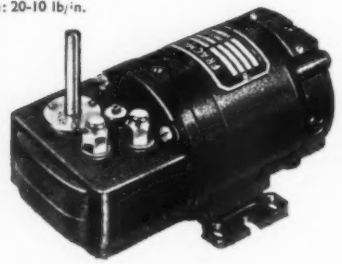

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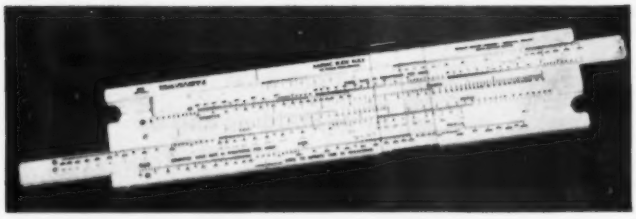

These Admiralty Research Laboratory Crown Copyright white plastic rules have eleven scales and twin reversible slides for calculating:-
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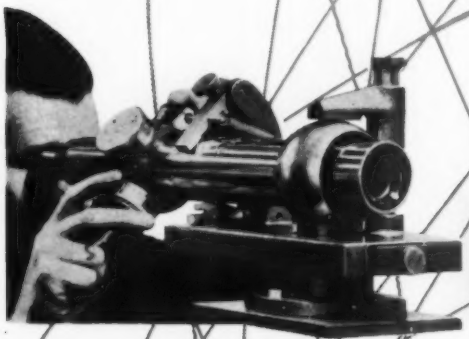

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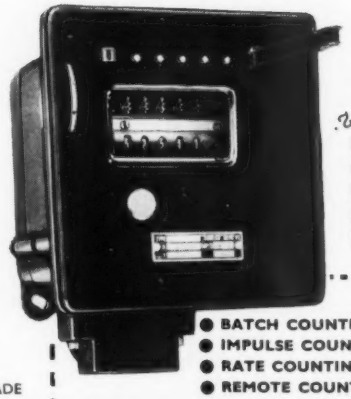
starts with counting



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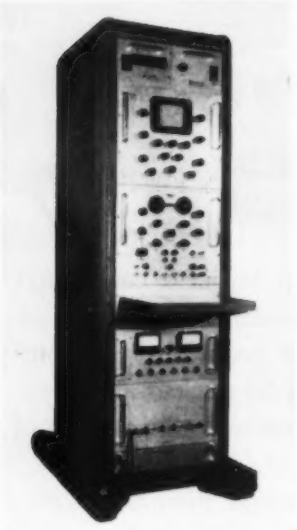

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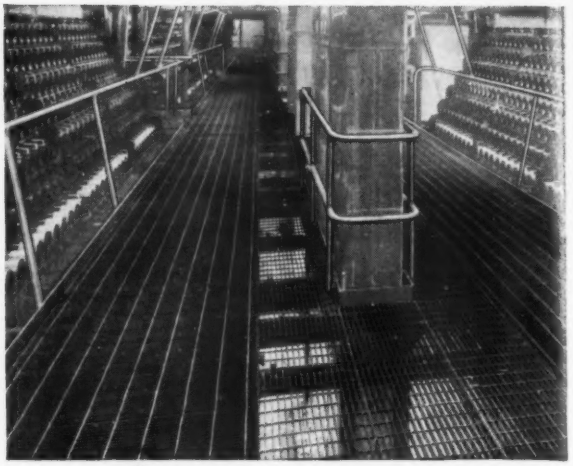

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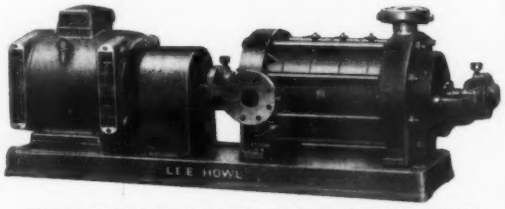

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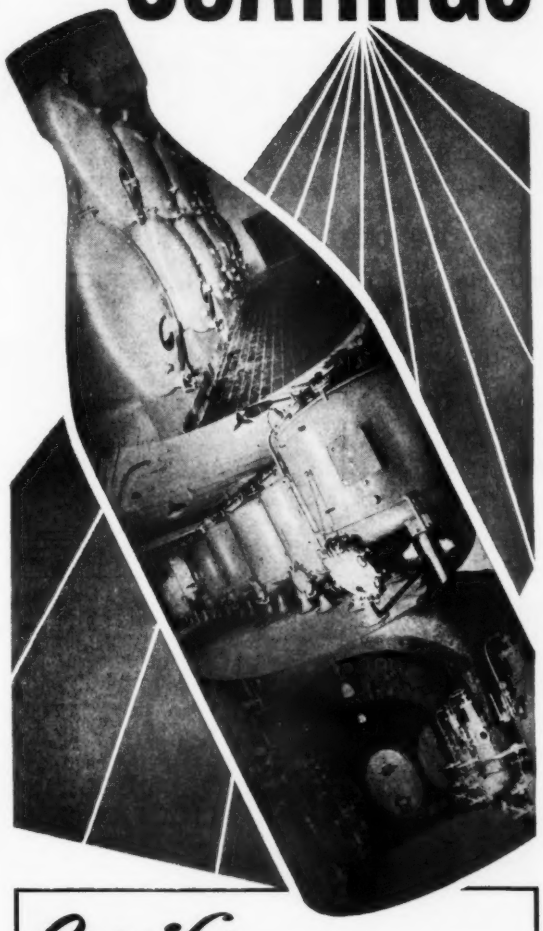

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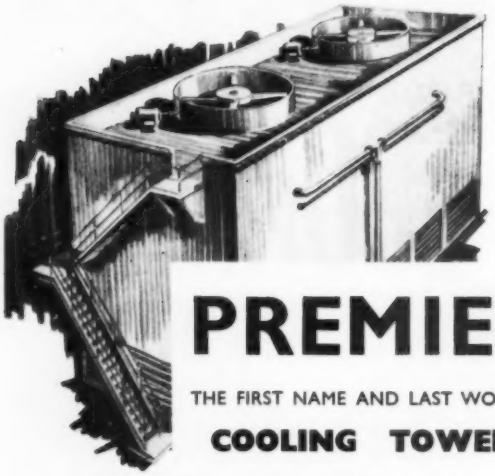

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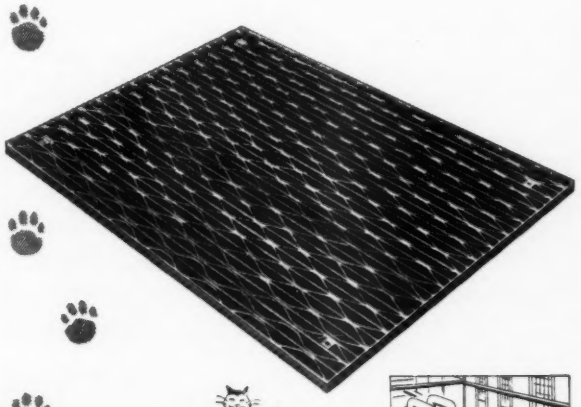

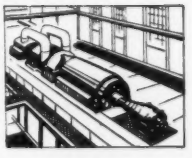

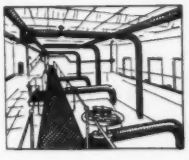

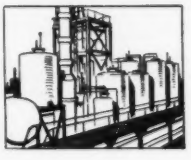

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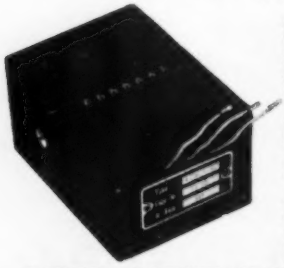

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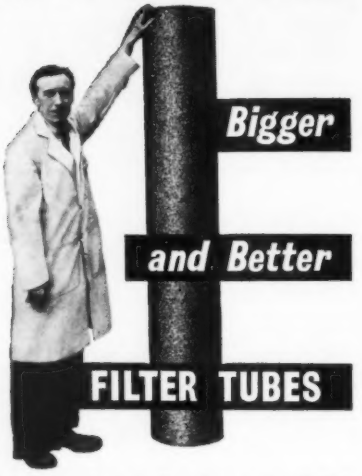

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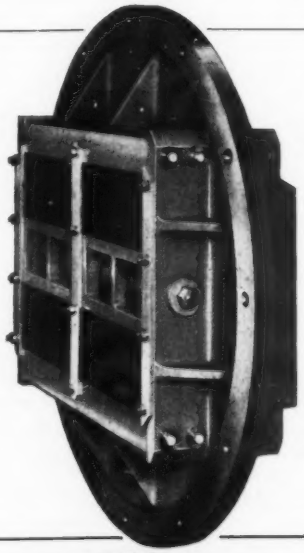

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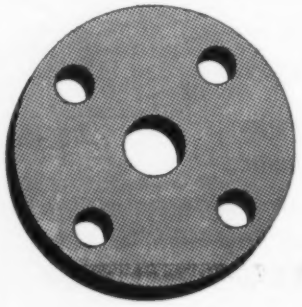

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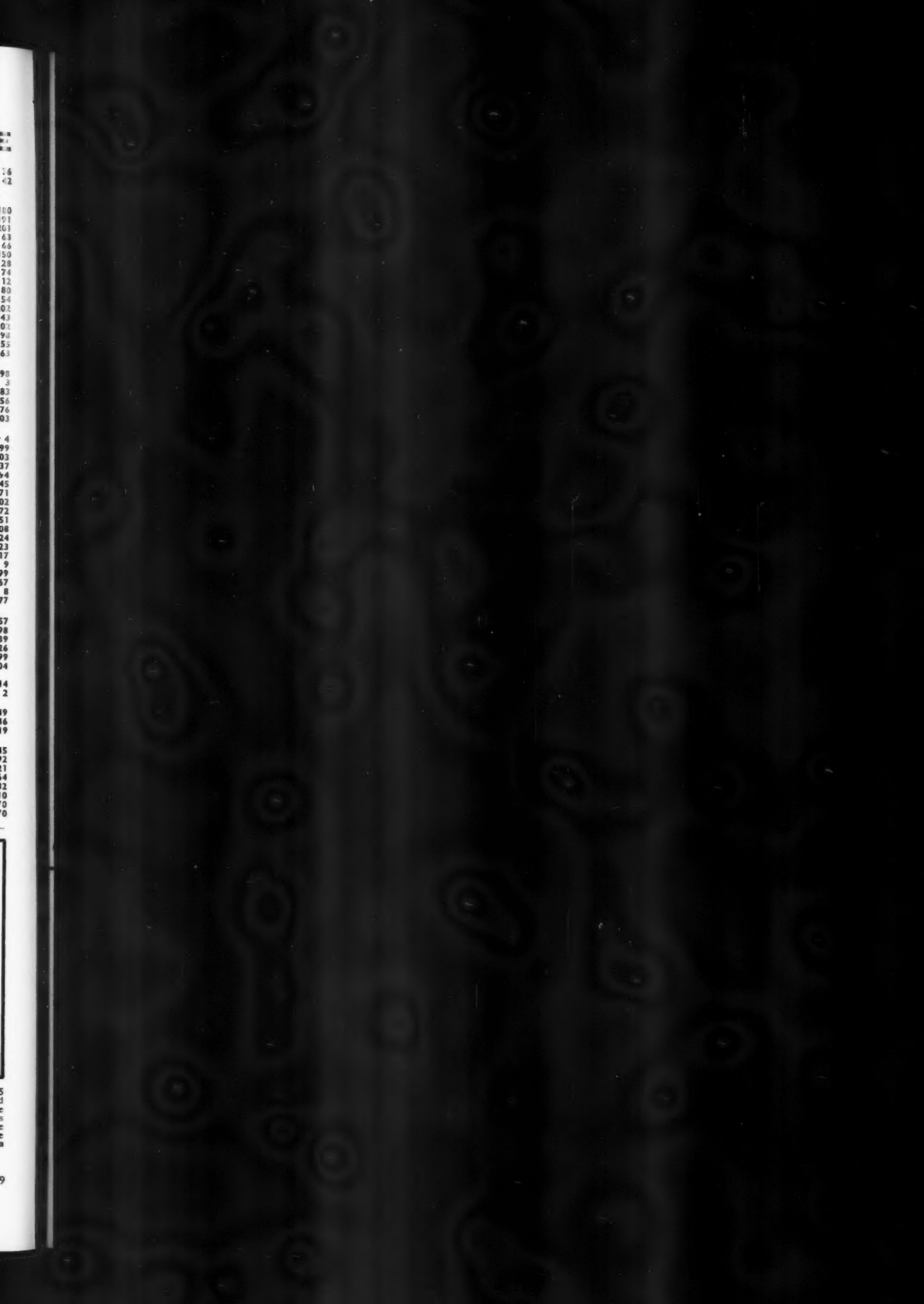

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222	252	282	312	342	372	402	432	462	492	522	552	582	612	642
223	253	283	313	343	373	403	433	463	493	523	553	583	613	643
224	254	284	314	344	374	404	434	464	494	524	554	584	614	644
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652	674	696	718	740	762	784	806	828	850	872				
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654	676	698	720	742	764	786	808	830	852	874				
655	677	699	721	743	765	787	809	831	853	875				
656	678	700	722	744	766	788	810	832	854	876				
657	679	701	723	745	767	789	811	833	855	877				
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662	684	706	728	750	772	794	816	838	860	882				
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PRODUCT CLASSIFICATION

Section 1

Materials, plant, equipment, services

ABSORBERS—FLUX FLATTENING
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English Electric Co Ltd, The
Mendip (Chemical Engineering) Ltd

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★ Circle *No 202* on reply card
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Bell Precision Engineering Co Ltd
British Thomson-Houston Co Ltd, The
English Electric Co Ltd, The
Hobson Ltd, H. M.
Lancashire Dynamo Electronic Products Ltd
Metropolitan-Vickers Electrical Co Ltd
Plessey Nucleonics Ltd
Weyers Bros Ltd

ACTUATORS—HYDRAULIC
★ Circle *No 203* on reply card
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Bell Precision Engineering Co Ltd
Chamberlain Industries Ltd
Electro-Hydraulics Ltd
Hobson Ltd, H. M.
Keelavite Hydraulics Ltd
Martonair Ltd
Plessey Nucleonics Ltd
Telehoist Ltd

ACTUATORS—PNEUMATIC
★ Circle *No 204* on reply card
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Baldwin Instrument Co Ltd
Bell Precision Engineering Co Ltd
Electro-Hydraulics Ltd
Elliott Brothers (London) Ltd
Fairey Aviation Co Ltd, The
Globe Pneumatic Engineering Co Ltd
Gordon & Co Ltd, James
Kent Ltd, George
Leybold Vacuum Sales Ltd
Martonair Ltd
Plessey Nucleonics Ltd

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Barytes (Shielding Products) Ltd
Cornwall Mills Ltd
United Chemicals (London) Ltd

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AIR COOLERS
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Birlec Ltd
Birwelco Ltd
Broom & Wade Ltd
Brown Fintube (GB) Ltd
Burnett & Lewis Ltd
Capper & Co Ltd, William H.
Carrier Engineering Co Ltd
Davidson & Co Ltd
English Electric Co Ltd, The
Harris (Birmingham) Ltd, F. & R. M.
Head Wrightson Processes Ltd
Heat Exchangers Ltd
Heat Transfer Ltd
Heenan & Froude Ltd
Howden & Co Ltd, James
Keith Blackman Ltd
Intermit Ltd
Lightfoot Refrigeration Co Ltd, The
Mancuna Engineering Ltd
Matthews & Yates Ltd
Morfax Ltd
Musgrave & Co Ltd
Newton, Chambers & Co Ltd
Plannair Ltd
Premier Cooler & Engineering Co Ltd, The
Spiral Tube & Components Ltd
Spiro-Gills Ltd
Sturtevant Engineering Co Ltd
Superheater Co Ltd, The
Thermocontrol Installations Co Ltd
United Air Coil Ltd
Weatherfoil Heating Systems Ltd
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Biddle Ltd, F. H.

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Birwelco Ltd
Burnett & Lewis Ltd
Cargocaire Ltd
Davidson & Co Ltd
English Electric Co Ltd, The
Hargreaves & Sons Ltd, Henry
Heat Transfer Ltd
Incandescent Heat Co Ltd
Keith Blackman Ltd
Kestner Evaporator & Engineering Co Ltd
Magnetic Equipment Co Ltd, The
Mancuna Engineering Ltd
Newton, Chambers & Co Ltd
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Birlec Ltd
Birwelco Ltd
Broom & Wade Ltd
Burnett & Lewis Ltd
Davidson & Co Ltd
Doulton Industrial Porcelains Ltd
Incandescent Heat Co Ltd
Intermit Ltd
IV Pressure Controllers Ltd
Kestner Evaporator & Engineering Co Ltd
Mancuna Engineering Ltd
Ozonair Engineering Co Ltd
Premier Cooler & Engineering Co Ltd, The
Silica Gel Ltd
Spembly Ltd
Standard & Pochin Bros Ltd, The
Sunvic Controls Ltd
Western Detail Mfrs Ltd
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Aerox Ltd
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Andrew Machine Construction Co Ltd, The
Birflo Controls Ltd
Bivac Air Co Ltd
Burnett & Lewis Ltd
Cape Asbestos Co Ltd
Carlson Ltd, John C.
Dallow Lambert & Co Ltd
Davidson & Co Ltd

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Heather Filters Ltd
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Intermit Ltd
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Keith Blackman Ltd
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Norgren Ltd, C. A.
Ozonair Engineering Co Ltd
Premier Cooler & Engineering Co Ltd
Sintered Products Ltd
South London Electrical Equipment Co Ltd
Stillite Products Ltd
Stream-Line Filters Ltd
Sturtevant Engineering Co Ltd
Supervents Ltd
Taylor Controls Ltd
Tilghman's Ltd
Vokes Ltd
Western Detail Mfrs Ltd
Williams & James (Engineers) Ltd
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Aerox Ltd
Air Control Installations Ltd
Burgess Products Co Ltd
Burnett & Lewis Ltd
Cape Asbestos Co Ltd
Carlson Ltd, John C.
Davidson & Co Ltd
Doulton Industrial Porcelains Ltd
Fibreglass Ltd
Intermit Ltd
IV Pressure Controllers Ltd
Jeffreys & Co Ltd, J.
Keith Blackman Ltd
Mancuna Engineering Ltd
Matthews & Yates Ltd
Ozonair Engineering Co Ltd
South London Electrical Equipment Co Ltd
Standard & Pochin Bros Ltd, The
Stillite Products Ltd
Sturtevant Engineering Co Ltd
Supervents Ltd
Visco Engineering Co Ltd
Vokes Ltd
Western Detail Mfrs Ltd
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Air-Maze Ltd
Andrew Machine Construction Co Ltd, The
Burgess Products Co Ltd
Davidson & Co Ltd
Intermit Ltd
IV Pressure Controllers Ltd
Keith Blackman Ltd
Mancuna Engineering Ltd
Matthews & Yates Ltd
Metal & Plastic Compacts Ltd
Premier Cooler & Engineering Co Ltd
Sturtevant Engineering Co Ltd
Thermotank Ltd
Visco Engineering Co Ltd
Vokes Ltd
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AIR FILTERS—VISCOUS, DISPOSABLE
★ Circle *No 212* on reply card
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Air-Maze Ltd
Davidson & Co Ltd
IV Pressure Controllers Ltd
Ozonair Engineering Co Ltd
Vokes Ltd
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AIR HEATERS—ELECTRIC
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AEW Ltd
Air-Maze Ltd
Appleby & Ireland Ltd
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Bastian & Allen Ltd
Biddle Ltd, F. H.
Bullows & Sons Ltd, Alfred
Controlled Heat & Air Ltd
Elfron (London) Ltd
Fenton, Byrn & Co Ltd
General Electric Co Ltd, The
Hanovia Lamps
Harris Engineering Co Ltd
Heat Transfer Ltd
Matthews & Yates Ltd
Metalectric Furnaces Ltd
Plannair Ltd
Royce Electric Furnaces Ltd
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AIR HEATERS—GAS
★ Circle *No 214* on reply card
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Biddle Ltd, F. H.
Birwelco Ltd
Brown Fintube (GB) Ltd
Budworth Ltd, David
Carrier Engineering Co Ltd
Controlled Heat & Air Ltd
Davidson & Co Ltd
Green & Son Ltd, E.
Harris Engineering Co Ltd
Heat Exchangers Ltd
Heat Transfer Ltd
Incandescent Heat Co Ltd
Keith Blackman Ltd
Newton, Chambers & Co Ltd
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Birwelco Ltd
Brown Fintube (GB) Ltd
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Harris Engineering Co Ltd
Heat Exchangers Ltd
Incandescent Heat Co Ltd
Newton, Chambers & Co Ltd
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Zephair Ltd

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Babcock & Wilcox Ltd
Biddle Ltd, F. H.
Birwelco Ltd
British Steam Specialties Ltd
Brown Fintube (GB) Ltd
Bullows & Sons Ltd, Alfred
Carrier Engineering Co Ltd
Controlled Heat & Air Ltd
Copperad Ltd
Davidson & Co Ltd
Fenton, Byrn & Co Ltd
Harris Engineering Co Ltd
Heat Exchangers Ltd
Heat Transfer Ltd
Howden & Co Ltd, James
Matthews & Yates Ltd
Musgrave & Co Ltd
Newton, Chambers & Co Ltd
Spiral Tube & Components Ltd
Spiro-Gills Ltd
Standard & Pochin Bros Ltd, The
Sturtevant Engineering Co Ltd
Thompson Water Tube Boilers Ltd, John
Weatherfoil Heating Systems Ltd
Worthington-Simpson Ltd

AIR HEATERS—WATER
★ Circle *No 217* on reply card
Air-Maze Ltd
Allen & Sons (Tipton) Ltd, W. G.
Andrew Machine Construction Co Ltd, The
Birwelco Ltd
British Steam Specialties Ltd
Brown Fintube (GB) Ltd
Bullows & Sons Ltd, Alfred
Carrier Engineering Co Ltd
Copperad Ltd
Davidson & Co Ltd
Fenton, Byrn & Co Ltd
Heat Transfer Ltd
Howden & Co Ltd, James
Keith Blackman Ltd
Matthews & Yates Ltd
Newton Chambers & Co Ltd
Spiral Tube & Components Ltd
Spiro-Gills Ltd
Standard & Pochin Bros Ltd, The
Ransome & Marles Bearing Co Ltd
Thompson Water Tube Boilers Ltd, John
Weatherfoil Heating Systems Ltd

AIR HOISTS
★ Circle *No 218* on reply card
Atlas Copco Ltd
Broom & Wade Ltd
Consolidated Pneumatic Tool Co Ltd, The
Globe Pneumatic Eng Co Ltd
Lang Pneumatic Ltd
Martonair Ltd
Sykes Ltd, Henry
United States Metallic Packing Co Ltd

ALTERNATORS (*See Generators etc*)

BATTERIES—ELECTRIC STORAGE
★ Circle *No 219* on reply card
Alto Instruments (GB) Ltd
Chloride Batteries Ltd
Crompton Parkinson Ltd
Siemens Edison Swan Ltd
Tudor Accumulator Co Ltd, The
Venner Ltd

BEARINGS—BALL
★ Circle *No 220* on reply card
BMB (Sales) Ltd
Brockhouse & Co Ltd, J.
Cooper Roller Bearings Co Ltd
Crofts (Engineers) Ltd
Deloro Stellite Ltd
Fischer Bearings Co Ltd
Hoffman Mfg Co Ltd
Hoyt Metal Co of Great Britain Ltd, The
Insley (London) Ltd
Pollard Bearings Ltd
Ransom & Marles Bearing Co Ltd
Skefko Ball Bearing Co Ltd, The

BEARINGS—CORE SUPPORT
★ Circle *No 221* on reply card
Pollard Bearings Ltd
Ransome & Marles Bearing Co Ltd

BEARINGS—FLEXIBLE
★ Circle *No 222* on reply card
Cooper Roller Bearings Co Ltd
Insley (London) Ltd
Pollard Bearings Ltd
Silentbloc Ltd
Skefko Ball Bearing Co Ltd, The

BEARINGS—JOURNAL
★ Circle *No 223* on reply card
Anti-Attrition Co Ltd
Armstrong Siddeley Motors Ltd
Cooper Roller Bearings Co Ltd
Deloro Stellite Ltd
Insley (London) Ltd

BEARINGS—ROLLER
★ Circle *No 224* on reply card
Allen & Sons (Tipton) Ltd, W. G.
British Timken Ltd
Cooper Roller Bearings Co Ltd
Croft (Engineers) Ltd
Fischer Bearings Co Ltd
Hoffmann Mfg Co Ltd
Insley (London) Ltd
Pollard Bearings Ltd
Ransome & Marles Bearing Co Ltd
Skefko Ball Bearing Co Ltd, The

BEARINGS—THRUST
★ Circle *No 225* on reply card
Armstrong Siddeley Motors Ltd
BMB (Sales) Ltd
Cooper Roller Bearings Co Ltd
Deloro Stellite Ltd
Fischer Bearings Co Ltd
Insley (London) Ltd
Pollard Bearings Ltd
Ransome & Marles Bearing Co Ltd
Skefko Ball Bearing Co Ltd, The

BLOWERS (*See Circulators—Gas*)

BOILERS—COAL & OIL FIRED
★ Circle *No 226* on reply card
Adamson & Co Ltd, Daniel
Babcock & Wilcox Ltd
Brockhouse & Co Ltd, J.
Brown Land Boilers Ltd, John
Clarke, Chapman & Co Ltd
Foster Wheeler Ltd
Foster Yates & Thom Ltd
Fraser & Fraser Ltd
GWB Furnaces Ltd (Oil Only)
Harland & Wolff Ltd
Head Wrightson Processes Ltd
International Combustion Ltd
Lloyd & Ross Ltd
Mitchell Engineering Ltd
Richardsons, Westgarth & Co Ltd
Robey & Co Ltd
Ruston & Hornsby Ltd
Savages Ltd
Simon-Carves Ltd
Sykes Ltd, Henry
Thermocontrol Installations Co Ltd
Thompson Water Tube Boilers Ltd, John
Thompson (Wolverhampton) Ltd, John
Yarrow & Co Ltd

BOILERS—ELECTRODE
★ Circle *No 227* on reply card
Bastian & Allen Ltd
Brown Land Boilers Ltd, John
Butterfield Ltd, W. P.
Foster Wheeler Ltd
Head Wrightson Processes Ltd
Robey & Co Ltd

BRUSHWARE—INDUSTRIAL
★ Circle *No 228* on reply card
Baddeley Engineering Co Ltd, D. S.
Dendix Brushes Ltd
Gem Power Brushes Ltd
Industrial Descaling Tools Ltd
Kleen-E-Ze Brush Co Ltd

BUBBLE CAPS & TRAYS
★ Circle *No 229* on reply card
Allen & Sons (Tipton) Ltd, W. G.
APV Co Ltd, The
Babcock & Wilcox Ltd
Bennett Sons & Shears Ltd
Blundell & Crompton Ltd
Constructors—John Brown Ltd
Foster Wheeler Ltd
Fraser & Co Ltd, W. J.
Hathernware Ltd
International Meehanite Metal Co Ltd, The
Metal Propellers Ltd
Motherwell Bridge & Engineering Co Ltd
Newton, Chambers & Co Ltd
Nuclear Engineering Ltd
QVF Ltd

BURST SLUG DETECTION APPARATUS
(*See Gas Sampling Plant, Sec. 2*)

CABLES—ELECTRIC
★ Circle *No 230* on reply card
ASEA Electric Ltd
British Insulated Callender's Cables Ltd
Crompton Parkinson Ltd
Geipel Ltd, William
General Electric Co Ltd, The
Henley's Telegraph Works Co Ltd, W. T.
Irish Cables Ltd
Johnson & Phillips Ltd
Kaye Ltd, E. & E.
Leland Instruments Ltd
Pyrotenax Ltd (mineral insulated)
Siemens Edison Swan Ltd
Southern Forge Ltd (aluminium alloy)
Standard Telephones & Cables Ltd
Tangyes Ltd (all types)
Telegraph Construction & Maintenance Co Ltd
TI Nuclear Engineering Ltd
Wandles de Cable Works Ltd
Western Detail Mfrs Ltd

CABLES—HOIST
★ Circle *No 231* on reply card
British Insulated Callender's Cables Ltd
Cable Joiners Ltd
Telegraph Construction & Maintenance Co Ltd,

CALANDRIAS
★ Circle *No 232* on reply card
APV Co Ltd, The
Ashmore, Benson, Pease & Co Ltd
Babcock & Wilcox Ltd
Balfour & Co Ltd, Henry
Bawn & Co Ltd, W. B.
Bennett Sons & Shears Ltd
Blundell & Crompton Ltd
Butterfield Ltd, W. P.

CALANDRIAS—*continued*
Davey, Paxman & Co Ltd
Fraser & Co Ltd, W. J.
Harvey & Co (London) Ltd, G. A.
Heat Exchangers Ltd
Heat Transfer Ltd
Kestner Evaporator & Engineering Co Ltd
Metal Propellers Ltd
Morgan Crucible Co Ltd, The
Newton Chambers & Co Ltd
Nuclear Engineering Ltd
Q.V.F. Ltd
Robertson & Ferguson Ltd
Simon-Carves Ltd
Stainless Steel Vessels (London) Ltd
Thompson (Dudley) Ltd, John

CARBON PRODUCTS
★ Circle *No 233* on reply card
British Acheson Electrodes Ltd
General Refractories Ltd
Leland Instruments Ltd
Morgan Crucible Co Ltd
Powell Duffryn Carbon Products Ltd
Spembly Ltd

CASTINGS—FERROUS *(See Steel)*

CASTINGS—NON-FERROUS
★ Circle *No 234* on reply card
Andrews & Platt (Engineers) Ltd (all types)
Anti-Attrition Co Ltd (all types)
Appleton & Howard Ltd (bronze & lead)
Armstrong Siddeley Motors Ltd
Armstrong Whitworth (Met. Ind.) Ltd
Ashwell & Nesbit Ltd
Blundell & Crompton Ltd (bronze, gunmetal, aluminium)
British Steam Specialties Ltd (gunmetal)
Brockhouse & Co Ltd, J. (all types)
Consolidated Zinc Corp (Sales) Ltd
Crosfield & Sons Ltd, Joseph
Deloro Stellite Ltd (cobalt & nickel base)
English Electric Co Ltd, The (all types)
Fullers' Earth Union Ltd, The
Grey & Marten Ltd
Harland & Wolff Ltd (all types)
High Duty Alloys Ltd (aluminium alloy)
Hindle & Sons Ltd, Joshua (bronze, nickel, monel)
Imperial Chemical Industries Ltd
Langley Alloys Ltd (aluminium bronze)
Mills Packard Construction Co Ltd (lead)
Millspaugh Ltd (all types)
Monsanto Chemicals Ltd
Napier & Son Ltd, D.
Robertson & Co Ltd, W. H. A. (aluminium, brass, bronze, gunmetal, aluminium-bronze, manganese-bronze, phosphor-bronze)
Ryder & Co (Manchester) Ltd, Thomas (all types)
Sheffield Smelting Co Ltd, The (light alloys)

CELLS—ELECTROLYTIC
★ Circle *No 235* on reply card
Aerox Ltd
Doulton Industrial Porcelains Ltd
Hathernware Ltd
Imperial Chemical Industries Ltd
International Electrolytic Plant Co Ltd, The
Morgan Crucible Co Ltd, The
Simon-Carves Ltd

CELLS—HOT
★ Circle *No 236* on reply card
Nuclear Engineering Ltd
Spembly Ltd

CENTRIFUGES—INDUSTRIAL
★ Circle *No 237* on reply card
Aerox Ltd
Lang London Ltd
Scientific Furnishings Ltd
Shandon Scientific Co Ltd
Sharples Centrifuges Ltd
Vicsons Ltd.

CERAMICS
★ Circle *No 238* on reply card
Aerox Ltd
Doulton Industrial Porcelains Ltd
English Clays, Lovering Pochin & Co Ltd
Hathernware Ltd
Leland Instruments Ltd
Lodge Plugs Ltd
Morgan Crucible Co Ltd, The
Podmore & Sons, Ltd, W.
Steatite & Porcelain Products Ltd
Technical Ceramics Ltd
Thermal Syndicate Ltd, The

CERMETS
★ Circle *No 239* on reply card
Morgan Crucible Co Ltd, The
Technical Ceramics Ltd

CHARGE MACHINES—REACTOR FUEL
★ Circle *No 240* on reply card
Chatwood-Milner Ltd
English Electric Co Ltd, The
Flight Refuelling Ltd
Motherwell Bridge & Engineering Co Ltd, The
Strachan & Henshaw Ltd
Thompson Ordnance Co, John

CHARGE PANS
★ Circle *No 241* on reply card
APV Co Ltd
Chatwood-Milner Ltd
English Electric Co Ltd, The
Geigy Co Ltd, The
International Meechanite Metal Co Ltd

CHEMICALS—INDUSTRIAL
★ Circle *No 242* on reply card
Albright & Wilson Ltd
Allen & Sons (Poplar) Ltd, Frederick
Borax Consolidated Ltd
British Industrial Solvents Ltd
BX Plastics Ltd

CHEMICALS—INDUSTRIAL—*continued*
Carnegies of Welwyn Ltd
Consolidated Zinc Corp (Sales) Ltd
Crosfield & Sons Ltd, Joseph
Distillers Co Ltd, The
Fullers' Earth Union Ltd, The
General Chemical & Pharmaceutical Co Ltd, The
Gurr Ltd, Edward
Hopkin & Williams Ltd (analytical)
Howards of Ilford Ltd
Imperial Chemical Industries Ltd
Johnson, Matthey & Co Ltd
Laporte Chemicals Ltd
Lunevale Products Ltd
Midland Silicones Ltd
Monsanto Chemicals Ltd
New Metals & Chemicals Ltd
North Hill Plastics Ltd (weld cleaner)
Page & Co Ltd, Chas.
Shell Chemical Co Ltd
Spencer Chapman & Messel Ltd
Staveley Iron & Chemical Co Ltd, The
Thompson & Capper Ltd (pelleted)

CHEMICALS—ORGANIC
★ Circle *No 243* on reply card
Abril Corporation (Great Britain) Ltd
Albright & Wilson Ltd (tributyl phosphate & dialkyl phosphates)
Allen & Sons (Poplar) Ltd, Frederick
Borax Consolidated Ltd
British Industrial Solvents Ltd
Carnegies of Welwyn Ltd
Consolidated Zinc Corp (Sales) Ltd
Distillers Co Ltd, The
Geigy Co Ltd, The
General Chemical & Pharmaceutical Co Ltd, The
Gurr Ltd, Edward
Hopkin & Williams Ltd (analytical and
Howards of Ilford Ltd
Imperial Chemical Industries Ltd
New Metals & Chemicals Ltd
Nuclear Enterprises (GB) Ltd
Page & Co Ltd, Chas.
Shell Chemical Co Ltd
Staveley Iron & Chemical Co Ltd, The

CHLORINATION PLANT
★ Circle *No 244* on reply card
Candy Filter Co Ltd, The
Heat Transfer Ltd
QVF Ltd
Wallace & Tiernan Ltd

CIRCULATORS—GAS, AXIAL FLOW
★ Circle *No 245* on reply card
Adamson & Co Ltd, Daniel
Air Control Installations Ltd
Alldays & Onions Ltd
Armstrong Siddeley Motors Ltd
British Thomson-Houston Co Ltd, The
Bryan Donkin Co Ltd, The
Callow (Engineers) Ltd, F. E.
Crossley Bros Ltd
Davidson & Co Ltd
ECD Ltd
English Electric Co Ltd
General Electric Co Ltd, The
Hopkins & Co Ltd, F.
Howden & Co Ltd, James
Johnson, Bromley & Co Ltd
Keith Blackman Ltd
Lacy-Hulbert & Co Ltd
Matthews & Yates Ltd
Musgrave & Co Ltd
Northey Rotary Compressors Ltd
Nuclear Power Plant Co Ltd, The
Parolle Electrical Plant Co Ltd
Parsons & Co Ltd, C. A.
Plannair Ltd
Ruston & Hornsby Ltd
Sturtevant Engineering Co Ltd
Wade Engineering Ltd
Western Detail Mfrs Ltd

CIRCULATORS—GAS, CENTRIFUGAL
★ Circle *No 246* on reply card
Adamson & Co Ltd, Daniel
Air Control Installations Ltd
Alldays & Onions Ltd
British Thomson-Houston Co Ltd, The
Bryan Donkin Co Ltd, The
Callow (Engineers) Ltd, F. E.
Crossley Bros Ltd
Davidson & Co Ltd
ECD Ltd
General Electric Co Ltd, The
Hopkins & Co Ltd, F.
Howden & Co Ltd, James
Johnson, Bromley & Co Ltd
Keith Blackman Ltd
Lacy-Hulbert & Co Ltd
Matthews & Yates Ltd
Musgrave & Co Ltd
Northey Rotary Compressors Ltd
Nuclear Power Plant Co Ltd, The
Parolle Electrical Plant Co Ltd
Parsons & Co Ltd, C. A.
Plannair Ltd
Reavell & Co Ltd
Ruston & Hornsby Ltd
Service Electric Co Ltd
Standard & Pochin Bros Ltd, The
Sturtevant Engineering Co Ltd
Wade Engineering Ltd
Western Detail Mfrs Ltd
Whittaker Hall & Co (1929) Ltd

CLASSIFIERS
★ Circle *No 247* on reply card
General Electric Co Ltd, The
Heat Transfer Ltd
QVF Ltd
Sharples Centrifuges Ltd

CLEANING EQUIPMENT—BOILER & HEAT EXCHANGER
★ Circle *No 248* on reply card
Airnesco Products Ltd
Gem Power Brushes Ltd

CLEANING EQUIPMENT—BOILER & HEAT EXCHANGER—*continued*
General Descaling Co Ltd
Industrial Descaling Tools Ltd
Keith Blackman Ltd
Kleen-E-Ze Brush Co Ltd

COLUMN PACKINGS
★ Circle *No 249* on reply card
Constructors John Brown Ltd (Spraypak)
Doulton Industrial Porcelains Ltd
Foster Wheeler Ltd
Glass Developments Ltd
Griffin & George Ltd
Hathernware Ltd
Nuclear Engineering Ltd
QVF Ltd
Powell Duffryn Carbon Products Ltd
Redweld Ltd
Scientific Furnishings Ltd
Thermal Syndicate Ltd, The
TI Nuclear Engineering Ltd
Turner Bros. Asbestos Co Ltd

COLUMNS—ABSORPTION
★ Circle *No 250* on reply card
Adamson & Co Ltd, Daniel
APV Co Ltd, The
Ashmore, Benson, Pease & Co
Babcock & Wilcox Ltd
Butterworth Ltd, W. P.
Costain-John Brown Ltd
Davey, Paxman & Co Ltd
Doulton Industrial Porcelains Ltd
Extrudex Ltd
Foster, Yates & Thom Ltd
Hall & Co Ltd, Matthew
Harris (Birmingham) Ltd, F. & R. M.
Hathernware Ltd
Head Wrightson Processes Ltd
Heat Transfer Ltd
Jenkins & Co Ltd, Robert
Kestner Evaporator & Engineering Co Ltd
Marson Excelsior Ltd
Metal Propellers Ltd
Mendip (Chemical Engineering) Ltd
Motherwell Bridge & Engineering Co Ltd, The
Newton, Chambers & Co Ltd
Powell Duffryn Carbon Products Ltd
QVF Ltd
Redweld Ltd
Rye-Arc Ltd
Scientific Furnishing Ltd
Simon-Carves Ltd
Thermal Syndicate Ltd, The
Thompson (Dudley) Ltd, John
Thompson (Wolverhampton) Ltd, John

COLUMNS—DISTILLATION
★ Circle *No 251* on reply card
Apex Construction Ltd
APV Co Ltd, The
Ashmore, Benson, Pease & Co
Babcock & Wilcox Ltd
Balfour & Co Ltd, Henry
Bennett Sons & Shears Ltd
Blundell & Crompton Ltd
Butterfield Ltd, W. P.
Costain-John Brown Ltd
Davey, Paxman & Co Ltd
Doulton Industrial Porcelains Ltd
Extrudex Ltd
Foster, Yates & Thom Ltd
Fraser & Co Ltd, W. J.
Glass Developments Ltd
Griffin & George Ltd
Hall & Co Ltd, Matthew
Harvey & Co (London) Ltd, G. A.
Head Wrightson Processes Ltd
Heat Transfer Ltd
Horseley Bridge & Thomas Piggott Ltd
Jenkins & Co Ltd, Robert
Leybold Vacuum Sales Ltd
Marston Excelsior Ltd
Metal Propellers Ltd.
Motherwell Bridge & Engineering Co Ltd
Newton, Chambers & Co Ltd
Nuclear Engineering Ltd
QVF Ltd
Powell Duffryn Carbon Products Ltd
Ryder & Co (Manchester) Ltd, Thomas
Rye-Arc Ltd
Scientific Furnishings Ltd
Simon-Carves Ltd
Stainless Steel Vessels (London) Ltd
Thermal Syndicate Ltd, The
Thompson (Dudley) Ltd, John
Thompson (Wolverhampton) Ltd, John
Watson & Co Ltd, Robert

COLUMNS—ION EXCHANGE
★ Circle *No 252* on reply card
Colborne Engineering Co Ltd, The
Doulton Industrial Porcelains Ltd
Extrudex Ltd
Foster, Yates & Thom Ltd
Griffin & George Ltd
Hall & Co Ltd, Matthew
Head Wrightson Processes Ltd
Heat Transfer Ltd
Marston Excelsior Ltd
Palatine Tool & Engineering Co (Surbiton) Ltd
Permutit Co Ltd, The
QVF Ltd
Rye-Arc Ltd
Scientific Furnishings Ltd
Thompson-Kennicott Ltd, John

COLUMNS—SOLVENT EXTRACTION
★ Circle *No 253* on reply card
Apex Construction Ltd
APV Co Ltd, The
Ashmore, Benson, Pease & Co
Bennett Sons & Shears Ltd
Butterfield Ltd, W. P.
Davey, Paxman & Co Ltd
Extrudex Ltd
Foster, Yates & Thom Ltd

COLUMNS—SOLVENT EXTRACTION *—continued*
Fraser & Co Ltd, W. J.
Hall & Co Ltd, Matthew
Head Wrightson Processes Ltd
Heat Transfer Ltd
Marston Excelsior Ltd
QVF Ltd
Rye-Arc Ltd
Simon-Carves Ltd
Thompson (Dudley) Ltd, John
Thompson (Wolverhampton) Ltd, John

COMPRESSORS—AIR
★ Circle *No 254* on reply card
Adamson & Co Ltd, Daniel
Aeraspray Associated Ltd
Air Pumps Ltd
Alley & MacLellan Ltd
Ashworth & Parker Ltd
Atlas Copco Ltd
Belliss & Morcom Ltd
B.E.N. Patents Ltd
British Thomson-Houston Co Ltd, The
Broom & Wade Ltd
Brotherhood Ltd, Peter
Budworth Ltd, David
Chamberlain Industries Ltd
Chatwood-Milner Ltd
Consolidated Pneumatic Tool Co Ltd, The
CT (London) Ltd (glandless & leakproof)
ECD Ltd
Edwards High Vacuum Ltd
English Electric Co Ltd, The
Hamworthy Engineering Ltd
Harland & Wolff Ltd
Holland Engineering Co Ltd, B. A.
Howden & Co Ltd, James
Keith Blackman Ltd
Leybold Vacuum Sales Ltd
Lloyd & Ross Ltd
Metropolitan-Vickers Electrical Co Ltd
Northey Rotary Compressors Ltd
Parsons & Co Ltd, C. A.
Reavell & Co Ltd
Richardsons, Westgarth & Co Ltd
Robey & Co Ltd
Ruston & Hornsby Ltd
Tecalemit, Ltd
Tilghman's Ltd
Wade Engineering Ltd
Weir Ltd, G. & J.
Whittaker Hall & Co (1929) Ltd
Williams & James (Engineers) Ltd
Worthington-Simpson Ltd

COMPRESSORS—GAS
★ Circle *No 255* on reply card
Alley & MacLellan Ltd
Armstrong Siddeley Motors Ltd
Bell Precision Engineering Co Ltd
Belliss & Morcom Ltd
British Thomson-Houston Co Ltd, The
Brotherhood Ltd, Peter
Bryan Donkin Co Ltd, The
CT (London) Ltd (glandless & leakproof)
ECD Ltd
Hamworthy Engineering Ltd
Harland & Wolff Ltd
Holland Engineering Co Ltd, B. A.
Howden & Co Ltd, James
Lloyd & Ross Ltd
Metropolitan-Vickers Electrical Co Ltd
Northey Rotary Compressors Ltd
Parsons & Co Ltd, C. A.
Reavell & Co Ltd
Richardsons, Westgarth & Co Ltd
Robey & Co Ltd
Ruston & Hornsby Ltd
Tilghman's Ltd
Wade Engineering Ltd
Weir Ltd, G. & J.
Western Detail Mfrs Ltd
Whittaker Hall & Co (1929) Ltd
Worthington-Simpson Ltd

CONCRETE—INSULATING
★ Circle *No 256* on reply card
Chatwood-Milner Ltd
Curtis & Co, A. L.
Dickens Ltd, Stuart B.
General Refractories Ltd
Mears Bros (Contractors) Ltd
Price, Charles R.

CONCRETE SHIELDING BLOCKS
★ Circle *No 257* on reply card
Barytes (Shielding Products) Ltd
Chatwood-Milner Ltd
Mears Bros (Contractors) Ltd
Mitchell Engineering Ltd
Savage & Parsons Ltd
United Chemicals (London) Ltd

CONDENSERS—PROCESS
★ Circle *No 258* on reply card
Adamson, & Co Ltd, Daniel
Apex Construction Ltd
APV Co Ltd, The
Balfour & Co Ltd, Henry
Belliss & Morcom Ltd
Bennett Sons & Shears Ltd
Blundell & Crompton Ltd
Butterfield Ltd W. P.
Capper & Co Ltd, William H.
Clarke, Chapman & Co Ltd
Davey, Paxman & Co Ltd
Ferranti Ltd
Fraser & Co Ltd, W. J.
Harris (Birmingham) Ltd, F. & R. M.
Heat Transfer Ltd
Horseley Bridge & Thomas Piggott Ltd
Jenkins & Co Ltd, Robert
Marston Excelsior Ltd
Metal Propellers Ltd
Metropolitan-Vickers Electrical Co Ltd
Morgan Crucible Co Ltd, The
Newton, Chambers & Co Ltd
Nuclear Engineering Co Ltd
Parsons & Co Ltd, C. A.
Pearson & Sons Ltd, T. B.

CONDENSERS—PROCESS—*continued*
Plenty & Son Ltd
Power-Gas Corporation Ltd, The
QVF Ltd
Ryder & Co (Manchester) Ltd, Thos.
Scientific Furnishings Ltd
Serck Radiators Ltd
Simon-Carves Ltd
Stainless Steel Vessels (London) Ltd
Stanfield & Carver Ltd
Spiro-Gills Ltd
Thompson (Dudley) Ltd, John
Unit Superheater & Pipe Co Ltd
Weir Ltd, G. & J.
Wellington Tube Works Ltd
Worthington-Simpson Ltd

CONDENSERS—TURBINE
★ Circle *No 259* on reply card
Balfour & Co Ltd, Henry
Belliss & Morcom Ltd
Blundell & Crompton Ltd
British Thomson-Houston Co Ltd, The
Brotherhood Ltd, Peter
English Electric Co Ltd, The
Ferranti Ltd
Fraser & Co Ltd, W. J.
General Electric Co Ltd, The
Harland & Wolff Ltd
Heat Transfer Ltd
Imperial Chemical Industries Ltd (tubes and plates)
Jenkins & Co Ltd, Robert
Metropolitan-Vickers Electrical Co Ltd
Nuclear Power Plant Co. Ltd, The
Parsons & Co Ltd, C. A.
Pearson & Sons Ltd, T. B.
Richardsons, Westgarth & Co Ltd
Ryder & Co (Manchester) Ltd, Thos.
Serck Radiators Ltd
Stanfield & Carver Ltd
Telegraph Condenser Co Ltd, The
Vickers-Armstrongs (Engineers) Ltd
Weir Ltd, G. & J.
Wellington Tube Works Ltd
Worthington-Simpson Ltd

CONSULTING ENGINEERS *(See also Engineering Consultants)*
★ Circle *No 260* on reply card
Atkins & Partners, W. S.
Ewbank & Partners Ltd
Kennedy & Donkin
Merz & McLellan
Preece, Cardew & Rider

CONTRACTORS—air conditioning
★ Circle *No 261* on reply card
Air Control Installations Ltd
Andrew Machine Construction Co Ltd, The
Biddle Ltd, F. H.
Birlec Ltd
Birmingham & Blackburn Construction Co Ltd
Brightside Heating & Engineering Co Ltd
Bullows & Sons Ltd, Alfred
Carrier Engineering Ltd
Colt Ventilation Ltd
Davidson & Co Ltd
Extrudex Ltd
Hall & Co Ltd, Matthew
Hargreaves & Sons Ltd, Henry
Heat Transfer Ltd
Jeffreys & Co Ltd, J.
Mancuna Engineering Ltd
Matthews & Yates Ltd
Owen Power Plant Co
Sturtevant Engineering Co Ltd
Supervents Ltd
Teddington Industrial Equipment Ltd
Thermocontrol Installations Co Ltd
Thermotank Ltd
Visco Engineering Co Ltd, The
Walker & Co (Halifax) Ltd., P. M.
Weatherfoil Heating Systems Ltd
Western Detail Mfrs Ltd
Wykeham & Co Ltd, W.

CONTRACTORS—Building
★ Circle *No 262* on reply card
Balfour, Beatty & Co Ltd
Chivers & Sons Ltd, W. E.
Constructors-John Brown Ltd
Drake & Gorham Ltd
Holland and Hannen & Cubitts Ltd
Laing & Son Ltd, John
McAlpine & Sons Ltd, Sir Robert
Mitchell Engineering Ltd
Monk & Co Ltd, A.
Mowlem & Co Ltd, John
Nuclear Civil Constructors
Nuclear Power Plant Co Ltd, The
Price, Charles R.
Simon-Carves Ltd
Stokes, Taylor & Shaw Ltd
Taylor & Woodrow Construction Ltd
Trollope & Colls Ltd
United Steel Structural Co Ltd
Watson & Co Ltd, Robert
Whatlings Ltd

CONTRACTORS—Chemical Engineering
★ Circle *No 263* on reply card
Apex Construction Ltd.
Badger & Sons Ltd, E. B.
Bennett, Son & Shears Ltd
Blundell & Crompton Ltd
Constructors-John Brown Ltd
Hall & Co Ltd, Matthew
Head Wrightson & Co Ltd (Nuclear Power Div)
Head Wrightson Processes Ltd
Humphreys & Glasgow Ltd
Jenkinson Ltd, W. G.
Kellogg International Corporation
Kestner Evaporator & Engineering Co Ltd
Mendip (Chem. Eng.) Ltd
Mills Packard Construction Co Ltd
Mason Ltd, G. Samuel
Newton, Chambers & Co Ltd
Nuclear Chemical Plant Ltd

CONTRACTORS—Chemical Engineering—*continued*
Power-Gas Corporation Ltd
QVF Ltd
Shaw-Petrie Ltd
Simon-Carves Ltd.
Thompson (Dudley) Ltd, John
Walker Ltd, C. & W.
Ward, Ltd, Thos. W.
Wilson & Partners Ltd, A. C.
Winkworth Machinery Ltd
Taylor Woodrow Construction Ltd

CONTRACTORS—Civil Engineering
★ Circle *No 264* on reply card
Balfour, Beatty & Co Ltd
Cementation Co Ltd
Chivers & Sons Ltd, W. E.
Constructors-John Brown Ltd
Dorman Long (Bridge & Engineering) Ltd
Henderson & Co Ltd, John M.
Holland and Hannen & Cubitts Ltd
Howard & Co Ltd, John
Kier & Co Ltd, J. L.
Laing & Sons Ltd, John
McAlpine & Sons Ltd, Sir Robert
Mears Bros (Contractors) Ltd
Mitchell Engineering Ltd
Mowlem & Co Ltd, John
Monk & Co Ltd, A.
Nuclear Civil Constructors
Nuclear Power Plant Co Ltd, The
Price, Charles R.
Press & Son Ltd, William
Simon-Carves Ltd
Soil Mechanics Ltd (Piling)
Stokes, Taylor & Shaw Ltd
Taylor Woodrow Construction Ltd
Trollope & Colls Ltd
Turiff Construction Co Ltd
Whatlings Ltd

CONTRACTORS—Constructional Engineering
★ Circle *No 265* on reply card
Andrews & Platt (Engineers) Ltd
Appleby-Frodingham Steel Co
Austin & Sons (Dewsbury) Ltd, James
Bawn & Co Ltd, W. B. (Fabrication)
Birmingham & Blackburn Construction Co Ltd
Braby & Co Ltd, Frederick
Chamberlain Industries Ltd
Constructors-John Brown Ltd
Dorman Long (Bridge & Engineering) Ltd
Drake & Gorham Ltd
Findlay & Co Ltd, Alex.
Gardner & Co Ltd, J.
General Steel Group
Hall & Co Ltd, Matthew
Haworth (ARC) Ltd (Flooring)
Heat Exchangers Ltd
Hill & Smith Ltd
Hills (West Bromwich) Ltd
Horseley Bridge & Thomas Piggott Ltd
Humphreys & Glasgow Ltd
Laing & Son Ltd, John
Mitchell Engineering Ltd
Motherwell Bridge & Engineering Co Ltd, The
Mowlem & Co Ltd, John
Musgrave & Co Ltd
Newton, Chambers & Co Ltd
Nuclear Civil Constructors
Nuclear Power Plant Co Ltd, The
Redpath, Brown & Co Ltd
Savages Ltd
Simon-Carves Ltd
Stokes, Taylor & Shaw Ltd
Taylor Woodrow Construction Ltd
Thompson Industrial Constructions Ltd, John
Tileman & Co Ltd
Trollope & Colls Ltd
United Steel Companies Ltd, The
United Steel Structural Co Ltd
Walker Ltd, C. & W.
Ward Ltd, Thos. W.
Watson & Co Ltd, Robert
Webb & Sons Ltd, Joseph
Whatlings Ltd
Wood & Co Ltd, Edward
Wright, Anderson & Co Ltd

CONTRACTORS—Electrical Engineering
★ Circle *No 266* on reply card
Bailey & Co Ltd, N. G.
Balfour, Beatty & Co Ltd
Belmos Co Ltd, The
British Thomson-Houston Co Ltd, The
Cable Jointers Ltd
Cathodic Corrosion Control Ltd
Crompton Parkinson Ltd
EMI Electronics Ltd
English Electric Co Ltd, The
Ferguson Pailin Ltd
General Electric Co Ltd, The
Hall & Co Ltd, Matthew
Heywood & Co Ltd, S. H.
Ionic Instruments (London) Ltd
Leland Instruments Ltd
Metropolitan-Vickers Electrical Co Ltd
Philips Electrical Ltd
Read & Partners Ltd
Savage & Parsons Ltd
Scott & Co, James
Scaley Engineering Co Ltd
Service Electric Co Ltd
Simon-Carves Ltd
Stabilag Co Ltd, The
Sullivan Ltd, H. W.

CONTRACTORS—Instrumentation
★ Circle *No 267* on reply card
Allied Electronics Ltd
Appleby & Ireland Ltd
Bailey & Co Ltd, N. G.
Bryans Aeroquipment Ltd
Boulton Paul Aircraft Ltd
Cambridge Instrument Co Ltd
Cawkell Research & Electronics Ltd
Constructors John Brown Ltd
Crosby Valve & Engineering Co Ltd
Dowty Nucleonics Ltd

CONTRACTORS—Instrumentation—*continued*
Dynatron Radio Ltd
Ekco Electronics Ltd
Elliott Bros (London) Ltd
EMI Electronics Ltd
English Electric Co Ltd, The
Ericsson Telephones Ltd (Instrument Division)
General Electric Co Ltd, The
General Radiological Ltd
Gordon & Co Ltd, James
Grabb Parsons & Co Ltd, Sir Howard
Hall & Co Ltd, Matthew
Hawker Siddeley Nuclear Power Co Ltd
Honeywell-Brown Ltd
Hutcheon Duthie & Co Ltd, R.
Integra, Leeds & Northrup, Ltd
Ionic Instruments (London) Ltd
Isotope Developments Ltd
IV Pressure Controllers Ltd
KDG Instruments Ltd
Kent Ltd, George
Ketay Ltd
Measurement Ltd
Mullard Ltd
Negretti & Zambra Ltd
New Western (Engineering) Ltd
Nuclear Enterprises (GB) Ltd
Parkinson & Cowan Ltd
Plessey Nucleonics Ltd
Pye Ltd
Research & Control Instruments Ltd
Salford Electrical Instruments Ltd
Sealey Engineering Co Ltd
Short Bros & Harland Ltd
Simon-Carves Ltd
Southern Instruments (Computer Division)
Sunvic Controls Ltd
Teddington Industrial Equipment Ltd
Thermocontrol Installations Co Ltd
Thompson Instrument Co Ltd, John
Tinsley & Co Ltd, H.
Weyers Bros Ltd

CONTRACTORS—mechanical engineering
★ Circle *No 268* on reply card
Amal Ltd
Andrews & Platt (Engineers) Ltd
Armstrong Whitworth Aircraft Ltd, Sir W. G.
Bailey & Co Ltd, N. G.
Balfour, Beatty & Co Ltd
Blundell & Crompton Ltd
Birmingham & Blackburn Construction Co Ltd
Chamberlain Industries Ltd
Constructors John Brown Ltd
Cravens Ltd
Curran Ltd, John
Davenport Engineering Co Ltd, The
Davidson & Co Ltd
Electro-Hydraulics Ltd
English Electric Co Ltd, The
E.R.D. Engineering Co Ltd
Evans & Son (Portsmouth) Ltd, J.
General Steel Group
Foster Wheeler Ltd
Hall & Co Ltd, Matthew
Head Wrightson & Co Ltd (Nuclear Power Div)
Ionic Instruments (London) Ltd
Leland Instruments Ltd
Liquid Systems Ltd
Miller Ltd, P. & J.
Mitchell Engineering Ltd
Moore Ltd, W. & E.
Morfax Ltd
Palatine Tool & Engineering Co (Surbiton) Ltd
Paterson Hughes Engineering Co Ltd
Ross Ensign Ltd
Ryder & Co (Manchester) Ltd, Thomas
Savage & Parsons Ltd
Screw Machine Products Ltd (Machining)
Sealey Engineering Co Ltd
Simon-Carves Ltd
Stokes Taylor & Shaw Ltd
Sykes Ltd, Henry
Ward Ltd, Thos W.
Wilson & Son Ltd, Edward

CONTRACTORS—nuclear power station
★ Circle *No 269* on reply card
AEI-John Thompson Nuclear Energy Co Ltd
Atomic Power Constructions Ltd
English Electric, Babcock & Wilcox and Taylor Woodrow Nuclear Energy Co Ltd
General Electric, Simon-Carves Group
Humphreys & Glasgow Ltd
Mitchell Engineering Ltd
Nuclear Power Plant Co Ltd
Ruston & Kier group

CONTRACTORS—pipework
★ Circle *No 270* on reply card
Aiton & Co Ltd
Ashmore, Benson, Pease & Co
Avica Equipment Ltd
Babcock & Wilcox Ltd
Bailey & Co Ltd, N. G.
Birmingham & Blackburn Construction Co Ltd
Brightside Heating & Engineering Co Ltd
Capper & Co Ltd, William H.
Constructors John Brown Ltd
Extrudex Ltd
Foster Wheeler Ltd
General Steel Group
Hall & Co Ltd, Matthew
Head Wrightson & Co Ltd (Nuclear Power Div)
Horseley Bridge & Thomas Piggott Ltd
Humphreys & Glasgow Ltd
Jeffreys & Co Ltd, J.
Jenkins & Co Ltd, Robert
Kirk & Co (Tubes) Ltd
Lawrie Ltd, J. & T.
Liquid Systems Ltd
Low & Sons Ltd, Archibald
Marston Excelsior Ltd
Mendip (Chem. Eng.) Ltd
Metal Propellors Ltd
Mills Packard Construction Co Ltd
Millspaugh Ltd
Mitchell Engineering Ltd
Munro & Miller Ltd
Press & Son Ltd, William

CONTRACTORS—pipework—*continued*
QVF Ltd
Ryder & Co (Manchester) Ltd
Shaw-Petrie Ltd
Simmons & Hawker Ltd
Simon-Carves Ltd
Steels Engineering Products Ltd
Stewarts & Lloyds Ltd
Sykes Ltd, Henry
Talbot Stead Tube Co Ltd
Thompson (Pipework) Ltd, John
Unit Superheater & Pipe Co Ltd
Ward Ltd, Thos W.
Watson & Co Ltd, Robert

CONTROL DRIVES—REACTOR
★ Circle *No 271* on reply card
British Thomson-Houston Co Ltd, The
Chatwood-Milner Ltd
Electro-Hydraulics Ltd
Elliott Brothers (London) Ltd
English Electric Co Ltd, The
General Electric Co Ltd, The
Gordon & Co Ltd, James
Hawker Siddeley Nuclear Power Co Ltd
Hobson Ltd, H. M.
Kent Ltd, George
Metropolitan-Vickers Electrical Co Ltd
Nuclear Engineering Ltd
Nuclear Power Plant Co Ltd, The
Plessey Nucleonics Ltd
Pye Ltd
Research & Control Instruments Ltd
Reyrolle & Co Ltd, A.
Rolls-Royce Ltd
Screw Machine Products Ltd. (components)
Standard Telephones & Cables Ltd
Sunvic Controls Ltd

CONTROL RODS—REACTOR
★ Circle *No 272* on reply card
Accles & Pollock Ltd
Chatwood-Milner Ltd
English Electric Co Ltd, The
Hadfields Ltd
Hawker Siddeley Nuclear Power Co Ltd
Metropolitan-Vickers Electrical Co Ltd
Sunvic Controls Ltd
Talbot Stead Tube Co Ltd
TI Nuclear Engineering Ltd

CONTROL SYSTEMS—REACTOR
★ Circle *No 273* on reply card
Appleby & Ireland Ltd
Ardleigh Engineering Ltd
Arens Controls Ltd
British Thomson-Houston Co Ltd, The
Dowty Nucleonics Ltd
Ekco Electronics Ltd
Electro-Hydraulics Ltd
Elliott Bros (London) Ltd
English Electric Co Ltd, The
Ericsson Telephones Ltd
Evershed & Vignoles Ltd
Fairey Aviation Co Ltd
General Electric Co Ltd, The
General Radiological Ltd
Gordon & Co Ltd, James
Hall & Co Ltd, Matthew
Hawker Siddeley Nuclear Power Co Ltd
Hobson Ltd, H. M.
Honeywell-Brown Ltd
Integra, Leeds & Northrup Ltd
Kent Ltd, George
Ketay Ltd
Metropolitan-Vickers Electrical Co Ltd
Muirhead & Co Ltd
NGN Electrical Ltd
Plessey Nucleonics Ltd
Pye Ltd
Ramsey Engineering Co Ltd
Research & Control Instruments Ltd
Reyrolle & Co Ltd, A.
Rolls-Royce Ltd
Salford Electrical Instruments Ltd
Sperry Gyroscope Co Ltd
Sunvic Controls Ltd
Thermocontrol Installations Co Ltd

CONVEYORS—BULK MATERIAL
★ Circle *No 274* on reply card
Aerospray Associated Ltd
Aerox Ltd
Allen & Sons (Tipton) Ltd, W. G.
Andrews & Platt (Engineers) Ltd
Babcock & Wilcox Ltd
Birmingham & Blackburn Construction Co Ltd
Clarke, Chapman & Co Ltd
Distington Engineering Co Ltd
Fisher & Ludlow Ltd
General Electric Co Ltd, The
Harris (Birmingham) Ltd, F. & R. M.
Humphreys & Glasgow Ltd
Magnetic Equipment Co Ltd, The
Mitchell Engineering Ltd
Parker Mitchell Engineering Co Ltd
Paterson Hughes Engineering Co Ltd
Simon-Carves Ltd
Thompson Conveyor Co, John
Tilghman's Ltd
TI Nuclear Engineering Ltd
Turner Bros. Asbestos Co Ltd
United Steel Companies Ltd, The
Wilson & Partners Ltd, A. C.

CONVEYORS—ROLLER
★ Circle *No 275* on reply card
Andrews & Platt (Engineers) Ltd
Bennett Sons & Shears Ltd
Birmingham & Blackburn Construction Co Ltd
Cary Ltd, Wm. E.
Fisher & Ludlow Ltd
Manufacturers Equipment Co Ltd
Mitchell Engineering Ltd
Morrison, Marshall & Hill Ltd
Paterson Hughes Engineering Co Ltd
Teleflex Products Ltd
Thompson Conveyor Co, John
Tilghman's Ltd
TI Nuclear Engineering Ltd

COOLERS—AIR (*See Air Coolers*)

COOLERS—OIL
★ Circle *No 276* on reply card
Birwelco Ltd
Brown Fintube (GB) Ltd
English Electric Co Ltd, The
Head Wrightson Processes Ltd
Newton, Chambers & Co Ltd
Premier Cooler & Engineering Co Ltd, The
Spiro-Gills Ltd
Superheater Co Ltd, The
Visco Engineering Co Ltd
Worthington-Simpson Ltd

COOLANT METALS—BISMUTH
★ Circle *No 277* on reply card
Gardner & Co Ltd, Henry
Hawker Siddeley Nuclear Power Co Ltd

COOLANT METALS—POTASSIUM
★ Circle *No 278* on reply card
New Metals & Chemicals Ltd
Rolls-Royce Ltd

COOLANT METALS—SODIUM
★ Circle *No 279* on reply card
Imperial Chemical Industries Ltd

COOLING TOWERS—NATURAL DRAUGHT
★ Circle *No 280* on reply card
Brotherhood Ltd, Peter
Cooling Towers Ltd
Davenport Engineering Co Ltd, The
Mitchell Engineering Ltd
Premier Cooler & Engineering Co Ltd, The
Price, Charles R.
Visco Engineering Co Ltd

COOLING TOWERS—FORCED DRAUGHT
★ Circle *No 281* on reply card
Andrews & Platt Ltd
Brotherhood Ltd, Peter
Film Cooling Towers Ltd
Foster Wheeler Ltd
Head Wrightson Processes Ltd
Heenan & Froude Ltd
Premier Cooler & Engineering Co Ltd, The
Shaw Petrie Ltd
Visco Engineering Co Ltd
Worthington-Simpson Ltd

CORROSION PROTECTION
★ Circle *No 282* on reply card
Abril Corpn. (G.B.) Ltd
Albright & Wilson Ltd (nickel-phosphorous plating)
Berk & Co Ltd, F. W.—Schori Division (metal & plastic spray)
Birlec Ltd
Braby & Co Ltd, Fredr. (hot dip & galvanizing)
British Paints Ltd (paint)
Cathodic Corrosion Control Ltd (cathodic)
Chrome-Alloying Co Ltd (metal diffn.)
Constructors John Brown Ltd (Cathodic)
C. & P. Development Co, London, Ltd
Crane Packing Ltd
Crosfield & Sons Ltd, Joseph (chemical)
Detel Products Ltd (paint)
Electropol Processing Ltd (electropolishing)
Extrudex Ltd (plastic)
Garthwood Co Ltd (plastic)
General Descaling Co Ltd
Green & Son Ltd, E.
Grey & Marten Ltd
Metallisation Ltd (metal spray)
Motherwell Bridge & Engineering Co Ltd, The (metal spray)
North British Chemical Co Ltd (paint)
Protective Coatings Ltd
Powell Duffryn Carbon Products Ltd
Shell Chemicals Ltd
Telegraph Construction & Maintenance Co Ltd, The (plastic coatings)
Toolchrome Ltd (hard chrome deposition)
Wallace & Tiernan Ltd

COUPLINGS—FLEXIBLE
★ Circle *No 283* on reply card
Armstrong-Whitworth (Met. Ind.) Ltd
Avica Equipment Ltd
Avimo Ltd
British Thomson-Houston Co Ltd, The
Crofts (Engineers) Ltd
Fenner & Co Ltd, J. H.
High Pressure Components Ltd
Metalastik Ltd
Renold Chains Ltd
Ryder & Co (Manchester) Ltd, Thomas
Silentbloc Ltd
TI Nuclear Engineering Ltd
Whittaker Hall & Co (1929) Ltd

COUPLINGS—HYDRAULIC
★ Circle *No 284* on reply card
Avica Equipment Ltd
British Ermeto Corporation Ltd
Chamberlain Industries Ltd
Crofts (Engineers) Ltd
Filton Ltd
Fluidrive Engineering Co Ltd
Guyson Industrial Equipment Ltd
High Pressure Components Ltd
IV Pressure Controllers Ltd
Ryder & Co (Manchester) Ltd, Thomas
Spembly Ltd
TI Nuclear Engineering Ltd

COUPLINGS—PIPE
★ Circle *No 285* on reply card
Avica Equipment Ltd
Avimo Ltd
British Ermeto Corporation Ltd
Capper & Co Ltd, William H.
Globe Pneumatic Eng Co Ltd
Guyson Industrial Equipment Ltd

COUPLINGS—PIPE—*continued*
High Pressure Components Ltd
IV Pressure Controllers Ltd
Kirk & Co (Tubes) Ltd
QVF Ltd
Ryder & Co (Manchester) Ltd, Thomas
Stewarts & Lloyds Ltd
Talbot Stead Tube Co Ltd
TI Nuclear Engineering Ltd

CRANES
★ Circle *No 286* on reply card
Andrews & Platt (Engineers) Ltd
ASEA Electric Ltd
Babcock & Wilcox Ltd
British Industrial Engineering Co (Staffs) Ltd
Butters & Co Ltd
Carruthers & Co Ltd
Caswell Cranes & Erection Ltd
Clarke, Chapman & Co Ltd
Clayton Crane & Hoist Co Ltd
Clyde Crane & Booth Ltd
Elliston, Evans & Jackson Ltd (electro-mechanical & hydraulic brakes)
Fellows Bros Ltd
Fowler & Co (Leeds) Ltd, John
General Steel Group
Henderson & Co Ltd, John M.
Heywood & Co Ltd, S. H.
K. & L. Steelfounders & Engineers Ltd
King Ltd, Geo. W.
Matterson Ltd
Mitchell Engineering Ltd
Morris Ltd, Herbert
Morrison, Marshall & Hill Ltd
Motherwell Bridge & Engineering Co Ltd, The
Newton, Chambers & Co Ltd
Paterson Hughes Engineering Co Ltd
Steels Engineering Products Ltd
Strachan & Henshaw Ltd
Vaughan Crane Co Ltd, The
Ward Ltd, Thos. W.
Wharton Crane & Hoist Co Ltd, The

CRUCIBLES—INDUSTRIAL
★ Circle *No 287* on reply card
Baker Platinum Div, Engelhard Industries Ltd (platinum)
Carborundum Co Ltd, The (all types)
Fleischmann (London) Ltd
Laboratory Apparatus & Glass Blowing Co
Morgan Crucible Co Ltd, The (all types)
Morgan Refractories Ltd (all types)
Powell Duffryn Carbon Products Ltd (carbon & graphite)
Scientific Furnishings Ltd
Thermal Syndicate Ltd, The (Vitreosil & refractory)

CRUSHING PLANT
★ Circle *No 288* on reply card
Allen & Co Ltd, Edgar
Armstrong Whitworth (Met. Ind.) Ltd
Babcock & Wilcox Ltd
Callow (Engineers) Ltd, F. E.
Clarke, Chapman & Co Ltd
Evans & Son (Portsmouth) Ltd, J.
Follsain-Wycliffe Foundries Ltd
General Electric Co Ltd, The
Hadfields Ltd
Manesty Machines Ltd
Mansfield & Co Ltd, Frank
Mitchell Engineering Ltd
Pascall Engineering Co Ltd, The
Robey & Co Ltd
Sturtevant Engineering Co Ltd

DEAERATORS
★ Circle *No 289* on reply card
Allen Sons & Co Ltd, W. H.
Boby & Co Ltd, William
Heat Transfer Ltd
Hick, Hargreaves & Co Ltd
Jenkins & Co Ltd, Robert
Motherwell Bridge & Engineering Co Ltd, The
Metropolitan-Vickers Electrical Co Ltd
Newton, Chambers & Co Ltd
Permutit Co Ltd, The
Richardsons, Westgarth & Co Ltd
Simon-Carves Ltd
Thompson-Kennicott Ltd, John
Unit Superheater & Pipe Co Ltd, The
Vickers-Armstrongs (Engineers) Ltd
Weir Ltd, G. & J.
Worthington-Simpson Ltd

DEHUMIDIFICATION PLANT
★ Circle *No 290* on reply card
Air Control Installations Ltd
Andrew Machine Construction Co Ltd
Biddle Ltd, F. H.
Birlec Ltd
Burnett & Lewis Ltd
Cargocaire Ltd
Carrier Engineering Co Ltd
Crosfield & Sons Ltd, Joseph (silica gel)
Heat Transfer Ltd
Keith Blackman Ltd
Mancuna Engineering Co Ltd
Magnetic Equipment Co Ltd, The
Motherwell Bridge & Engineering Co Ltd, The
Peabody Ltd
Porter (Sales) Ltd, Alfred
Sturtevant Engineering Co Ltd
Thermocontrol Installations Co Ltd
Visco Engineering Co Ltd
Wykenham & Co Ltd, W.

DEMINERALIZATION PLANT
★ Circle *No 291* on reply card
Boby & Co Ltd, Wm.
Heat Transfer Ltd
Motherwell Bridge & Engineering Co Ltd, The
Permutit Co Ltd, The
Thompson-Kennicott Ltd, John

DESUPERHEATERS
★ Circle *No 292* on reply card
Babcock & Wilcox Ltd
Chesterfield Tube Co Ltd, The

DESUPERHEATERS—*continued*
Foster Wheeler Ltd
Gordon & Co Ltd, James
Heat Exchangers Ltd
Heat Transfer Ltd
Hopkinsons Ltd
Jenkins & Co Ltd, Robert
Motherwell Bridge & Engineering Co Ltd, The
Simon-Carves Ltd
Superheater Co Ltd, The
Unit Superheater & Pipe Co Ltd

DIAPHRAGMS—ELECTROLYTIC
★ Circle *No 293* on reply card
Aerox Ltd
Doulton Industrial Porcelains Ltd
Saunders Valve Co Ltd

DIESEL POWER PLANT
★ Circle *No 294* on reply card
Allen Sons & Co Ltd, W. H.
Belliss & Morcom Ltd
British Thomson-Houston Co Ltd, The
Crossley Bros Ltd
Davey, Paxman & Co Ltd
English Electric Co Ltd, The
Hamworthy Engineering Co Ltd (diesel-driven pumps)
Harland & Wolff Ltd
Hawker Siddeley Nuclear Power Co Ltd
Mirrlees, Bickerton & Day Ltd
Napier & Son Ltd, D.
Petbow Ltd
Ruston & Hornsby Ltd
Sykes Ltd, Henry

DIFFUSION PLANT
★ Circle *No 295* on reply card
Aerox Ltd
APV Co Ltd, The
Doulton Industrial Porcelains Ltd
Marston Excelsior Ltd

DISSOLVERS—FUEL ELEMENT
★ Circle *No 296* on reply card
Chesterfield Tube Co Ltd, The
Davey, Paxman & Co Ltd
Fraser & Co Ltd, W. J.
Heat Transfer Ltd
Lang London Ltd
QVF Ltd
Simon-Carves Ltd
Thompson (Wolverhampton) Ltd, John
TI Nuclear Engineering Ltd

DOORS—HEAVY SHIELDING
★ Circle *No 297* on reply card
Andrews & Platt (Engineers) Ltd
Chatwood-Milner Ltd
General Steel Group
Grazebrook & Co Ltd, M. & W.
Hall & Co Ltd, Matthew
Haywards Steel Doors Ltd
Liquid Systems Ltd
Marine & Industrial Plastics Ltd
Research & Control Instruments Ltd
Rye-Arc Ltd
Walker Ltd, C. & W.

DRAWING OFFICE EQUIPMENT
★ Circle *No 298* on reply card
Dargue Bros Ltd
Lawes Rabjonns Ltd

DUCTWORK—FLEXIBLE
★ Circle *No 299* on reply card
Avica Equipment Ltd
Flexible Ducting Ltd
Hall & Co Ltd, Matthew
Keith Blackman Ltd
Motherwell Bridge & Engineering Co Ltd, The
Palatine Tool & Engineering Co (Surbiton) Ltd
Ruston & Hornsby Ltd
Ryder & Co (Manchester) Ltd, Thomas
Thermotank Ltd
Thompson (Dudley) Ltd, John
Thompson (Wolverhampton) Ltd, John

DUCTWORK—METALLIC
★ Circle *No 300* on reply card
Aerospray Associated Ltd
Air Control Installations Ltd
Airnesco Products Ltd
Allen & Sons (Tipton) Ltd, W. G.
Andrew Machine Construction Co Ltd, The
Avica Equipment Ltd
Babcock & Wilcox Ltd
Bawn & Co Ltd, W. B.
Birmingham & Blackburn Construction Co Ltd
Birwelco Ltd
Blundell & Crompton Ltd
Braby & Co Ltd, Fredr.
Brown & Co Ltd, E. G.
Bullows & Sons Ltd, Alfred
Burgess Products Co Ltd
Butterfield Ltd, W. P.
Capper & Co Ltd, William H.
Carrilks & Sons Ltd
Cary Ltd, Wm. E.
Clarke, Chapman & Co Ltd
Controlled Heat & Air Ltd
Dallow, Lambert & Co Ltd
Davidson & Co Ltd
Freeman, Taylor Machines Ltd
General Steel Group
Greenwoods & Airvac Ventilating Co Ltd
Hall & Co Ltd, Matthew
Hargreaves & Sons Ltd, Henry
Harvey & Co (London) Ltd, G. A.
Head, Wrightson & Co Ltd
Howden & Co Ltd, James
Jeffreys & Co Ltd, J.
Jenkins & Co Ltd, Robert
Keith Blackman Ltd
Mancuna Engineering Ltd
Mills Packard Construction Co Ltd
Moore & Co Ltd, W. & E.
Morfax Ltd
Opperman Ltd, S. E.

DUCTWORK—METALLIC—*continued*
Owen Power Plant Co
Ozonair Engineering Co Ltd
Palatine Tool & Engineering Co (Surbiton) Ltd
Pearson & Sons Ltd, T. B.
Prat-Daniel (Stanmore) Ltd
Premier Cooler & Engineering Co Ltd
Ruston & Hornsby Ltd
Ryder & Co (Manchester) Ltd, Thomas
Rye-Arc Ltd
Scientific Furnishings Ltd
Southborough (Weybridge) Ltd
Stainless Steel Vessels (London) Ltd
Standard & Pochin Bros Ltd, The
Stokes Taylor & Shaw Ltd
Supervents Ltd
Thermotank Ltd
Thompson (Dudley) Ltd, John
Thompson (Wolverhampton) Ltd, John
Tirfor Ltd
Tupholme & Co Ltd, George E.
Visco Engineering Co Ltd, The
Walker & Co (Halifax) Ltd, P. M.
Watson & Co Ltd, Robert
Weatherfoil Heating Systems Ltd
Western Detail Mfrs Ltd
Wykenham & Co Ltd, W.

DUCTWORK—NON-METALLIC
★ Circle *No 301* on reply card
Air Control Installations Ltd
British Geon Ltd
BX Plastics Ltd
Doulton Industrial Porcelains Ltd
Extrudex Ltd
Flexible Ducting Ltd
Hall & Co Ltd, Matthew
Hathernware Ltd
Keith Blackman Ltd
Kestner Evaporator & Engineering Co Ltd
Mendip (Chemical Engineering) Ltd
QVF Ltd
Rediweld Ltd
Scientific Furnishings Ltd
Southborough (Weybridge) Ltd
Supervents Ltd
Thermoplastics Ltd
Yarrow & Co Ltd

DUST COLLECTORS—CYCLONE
★ Circle *No 302* on reply card
Air Control Installations Ltd
Allen & Co Ltd, Edgar
Allen & Sons (Tipton) Ltd, W. G.
Andrew Machine Construction Co Ltd, The
Bennett Sons & Shears Ltd
Berk & Co Ltd, F. W.—Schori Division
Birmingham & Blackburn Construction Co Ltd
Blundell & Crompton Ltd
Buell (1952) Ltd
Butterfield Ltd, W. P.
Carrier Engineering Co Ltd
Controlled Heat & Air Ltd
Dallow Lambert & Co Ltd
Davidson & Co Ltd
Hargreaves & Sons Ltd, Henry
Harvey & Co (London) Ltd, G. A.
Heat Transfer Ltd
Holmes & Co Ltd, W. C.
Howden & Co Ltd, James
Intermit Ltd
Keith Blackman Ltd
Mancuna Engineering Ltd
Mathews & Yates Ltd
Newton, Chambers & Co Ltd
Owen Power Plant Co
Ozonair Engineering Co Ltd
Power-Gas Corporation Ltd
Prat-Daniel (Stanmore) Ltd
Service Electric Co Ltd
Simon-Carves Ltd
Stainless Steel Vessels (London) Ltd
Standard & Pochin Bros Ltd, The
Sturtevant Engineering Co Ltd
Supervents Ltd
Tupholme & Co Ltd, George E.
Visco Engineering Co Ltd
Vokes Ltd
Walker & Co (Halifax) Ltd, P. M.
Weatherfoil Heating Systems Ltd
Wykenham & Co Ltd, W.

DUST COLLECTORS—ELECTROSTATIC
★ Circle *No 303* on reply card
Air Control Installations Ltd
Air-Maze Ltd
Chambers Filterbag Co Ltd, The
Harris Engineering Co Ltd
Head, Wrightson & Co Ltd
Howden & Co Ltd, James
Keith Blackman Ltd
Leland Instruments Ltd
Midland Heating & Ventilation Co Ltd
Prat-Daniel (Stanmore) Ltd
Simon-Carves Ltd
South London Electrical Equipment Co Ltd
Sturtevant Engineering Co Ltd

EFFLUENT TREATMENT PLANT
★ Circle *No 304* on reply card
Aerox Ltd
APV Co Ltd
Barytes (Shielding Products) Ltd
Bennett Sons & Shears Ltd
Boby & Co Ltd, William
Candy Filter Co Ltd, The
Crosfield & Sons Ltd, Joseph
Fraser & Co Ltd, W. J.
Fullers' Earth Union Ltd, The
Hall & Co Ltd, Matthew
Kestner Evaporator & Engineering Co Ltd
Mason (Chemical Engineers) Ltd, G. Samuel
Mendip (Chemical Engineering) Ltd
Newton, Chambers & Co Ltd
Permutit Co Ltd, The
Plessey Nucleonics Ltd
QVF Ltd
Sharples Centrifuges Ltd
Simon-Carves Ltd
Thompson-Kennicott Ltd, John

EJECTORS—AIR
★ Circle *No 305* on reply card
Bennett Sons & Shears Ltd
Blundell & Crompton Ltd
British Steam Specialties Ltd
English Electric Co Ltd, The
Foster Wheeler Ltd
Hathernware Ltd
Leybold Vacuum Sales Ltd
QVF Ltd
Powell Duffryn Carbon Products Ltd
Stanfield & Carver Ltd
Supervents Ltd
Weir Ltd, G. & J.
Western Detail Mfrs Ltd
Worthington-Simpson Ltd

ELECTRIC MOTORS—VARIABLE FREQUENCY
★ Circle *No 306* on reply card
British Thomson-Houston Co Ltd, The
Crompton Parkinson Ltd
Electric Construction Co Ltd, The
English Electric Co Ltd, The
General Electric Co Ltd, The
Klaxon Ltd
Lancashire Dynamo Electronic Products Ltd
Laurence, Scott & Electromotors Ltd
Metropolitan-Vickers Electrical Co Ltd

ENGINEERING CONSULTANTS (*See also Consulting Engineers*)
★ Circle *No 307* on reply card
APV Co Ltd, The
Bell Precision Engineering Co Ltd
Coniston Co, The
Falk & Co Ltd, M.
Hawker Siddeley Nuclear Power Co Ltd
Head Wrightson & Co Ltd (Nuclear Power Div)
Head Wrightson Processes Ltd
Humphreys & Glasgow Ltd
Leland Instruments Ltd
Mitchell Engineering Ltd
North West Machine Design Co Ltd
Palatine Tool & Engineering Co (Surbiton) Ltd
QVF Ltd
Southborough (Weybridge) Ltd
Spembly Ltd
Western Detail Mfrs Ltd

EVAPORATORS—CARBON DIOXIDE
★ Circle *No 308* on reply card
APV Co Ltd, The
Capper & Co Ltd, William H.
Carbon Dioxide Company, The
Chesterfield Tube Co Ltd
Heat Transfer Ltd
Kestner Evaporator & Engineering Co Ltd
Lloyd & Ross Ltd

EVAPORATORS—CHEMICAL
Aiton & Co Ltd
Apex Construction Ltd
Bennett Sons & Shears Ltd
Blundell & Crompton Ltd
Capper & Co Ltd, William H.
Chesterfield Tube Co Ltd, The
Davey, Paxman & Co Ltd
Fraser & Co Ltd, W. J.
Heat Transfer Ltd
Horseley Bridge & Thomas Piggott Ltd
Marston Excelsior Ltd
Metal Propellers Ltd
Nuclear Engineering Ltd
QVF Ltd
Simon-Carves Ltd
Stainless Steel Vessels (London) Ltd
Stanfield & Carver Ltd
Thompson (Dudley) Ltd, John
Weir Ltd, G. & J.
Worthington-Simpson Ltd

EVAPORATORS—POWER STATION
★ Circle *No 309* on reply card
Aiton & Co Ltd
Bennett Sons & Shears Ltd
Blundell & Crompton Ltd
Capper & Co Ltd, William H.
Chesterfield Tube Co Ltd, The
English Electric Co Ltd, The
Fraser & Co Ltd, W. J.
Heat Transfer Ltd
Richardsons, Westgarth & Co Ltd
Metropolitan-Vickers Electrical Co Ltd
Simon-Carves Ltd
Stainless Steel Vessels (London) Ltd
Stanfield & Carver Ltd
Vickers-Armstrongs (Engineers) Ltd
Weir Ltd, G. & J.
Worthington-Simpson Ltd

FANS—AXIAL FLOW
★ Circle *No 310* on reply card
Aerospray Associated Ltd
Air Control Installations Ltd
Airscrew Co & Jicwood Ltd, The
A.K. Fans Ltd
Alldays & Onions Ltd
Bullows & Sons Ltd, Alfred
Colt Ventilation Ltd
Davidson & Co Ltd
Extrudex Ltd
Fenton, Byrn & Co Ltd
General Electric Co Ltd, The
Green & Son Ltd, E.
Howden & Co Ltd, James
Jones & Stevens Ltd
Keith Blackman Ltd
Mathews & Yates Ltd
Midland Heating & Ventilation Co Ltd
Plannair Ltd
Ruston & Hornsby Ltd
Scientific Furnishings Ltd
Sturtevant Engineering Co Ltd
Supervents Ltd
Thermotank Ltd
Vent-Axia Ltd
Walker & Co (Halifax) Ltd, P. M.
Walker Bros (Wigan) Ltd
Woods of Colchester Ltd
Wykeham & Co Ltd, W.

FANS—CENTRIFUGAL
★ Circle *No 311* on reply card
Air Control Installations Ltd
Airscrew Co & Jicwood Ltd, The
Alldays & Onions Ltd
Andrew Machine Construction Co Ltd, The
Bullows & Sons Ltd, Alfred
Bryan Donkin Co Ltd, The
Dallow, Lambert & Co Ltd
Davidson & Co Ltd
Extrudex Ltd
General Electric Co Ltd, The
Hathernware Ltd
Howden & Co Ltd, James
Keith Blackman Ltd
Leland Instruments Ltd
Mathews & Yates Ltd
Midland Heating & Ventilation Co Ltd
Owen Power Plant Co
Prat-Daniel Ltd
Ruston & Hornsby Ltd
Scientific Furnishings Ltd
Service Electric Co Ltd
Standard & Pochin Bros Ltd, The
Sturtevant Engineering Co Ltd
Thermotank Ltd
Walker & Co (Halifax) Ltd, P. M.
Whittaker Hall & Co (1929) Ltd
Woods of Colchester Ltd
Wykeham & Co Ltd, W.

FANS—CONTRA-ROTATING
★ Circle *No 312* on reply card
Airscrew Co & Jicwood Ltd, The
Davidson & Co Ltd
General Electric Co Ltd, The
Keith Blackman Ltd
Woods of Colchester Ltd
Wykeham & Co Ltd, W.

FEED WATER HEATERS
★ Circle *No 313* on reply card
Babcock & Wilcox Ltd
Blundell & Crompton Ltd
Boby & Co Ltd, William
British Steam Specialties Ltd
Brown Fintube (GB) Ltd
Capper & Co Ltd, William H.
English Electric Co Ltd, The
General Electric Co Ltd, The
Green & Son Ltd, E.
Heat Exchangers Ltd
Heat Transfer Ltd
Metropolitan-Vickers Electrical Co Ltd
Newton, Chambers & Co Ltd
Nuclear Power Plant Co Ltd
Richardsons, Westgarth & Co Ltd
Simon-Carves Ltd
Spiro-Gills Ltd
Stanfield & Carver Ltd
Unit Superheater & Pipe Co Ltd, The
Vickers-Armstrongs (Engineers) Ltd
Weir Ltd, G. & J.
Worthington-Simpson Ltd

FILTER PRESSES
★ Circle *No 314* on reply card
KC Productions Ltd
Permutit Co Ltd

FILTERS—AIR (See Air Filters)

FILTERS—GAS
★ Circle *No 315* on reply card
Aerox Ltd
Air Control Installations Ltd
Air-Maze Ltd
British Filters Ltd
Callow (Engineers) Ltd, F. E.
Clarke, Chapman & Co Ltd
Doulton Industrial Porcelains Ltd
Endecotts (Filters) Ltd
Fairey Aviation Co Ltd, The
Incandescent Heat Co Ltd
Innes & Co (Darlington) Ltd
Mancuna Engineering Ltd
Metal & Plastic Compacts Ltd
Marston Excelsior Ltd
Nuclear Engineering Ltd
Ozonair Engineering Co Ltd
Power-Gas Corporation Ltd
Sintered Products Ltd
Standard & Pochin Bros Ltd, The
Stream-Line Filters Ltd
Vokes Ltd

FILTERS—LIQUID METAL
★ Circle *No 316* on reply card
Aerox Ltd
APV Co Ltd
Marston Excelsior Ltd
Metal & Plastic Components Ltd
Palatine Tool & Engineering Co (Surbiton) Ltd
Sintered Products Ltd

FILTERS—VACUUM
★ Circle *No 317* on reply card
Aerox Ltd
Air-Maze Ltd
APV Co Ltd
Carlson Ltd, John C.
Davey, Paxman & Co Ltd
Doulton Industrial Porcelains Ltd
Edwards High Vacuum Ltd
Eimco (Great Britain) Ltd
Endecotts (Filters) Ltd
Extrudex Ltd
Fleischmann (London) Ltd
Fraser & Co Ltd, W. J.
Heat Transfer Ltd
IV Pressure Controllers Ltd
Lacey-Hulbert & Co Ltd
Leybold Vacuum Sales Ltd
Mendip (Chem. Eng.) Ltd
N.G.N. Electrical Ltd
Norgren Ltd, C. A.
Pulsometer Engineering Co Ltd, The
Ruston & Hornsby Ltd
Sintered Products Ltd
Stream-Line Filters Ltd

FILTERS—WATER
★ Circle *No 318* on reply card
Aerox Ltd
Air-Maze Ltd
APV Co Ltd
Ashworth & Parker Ltd
Auto-Kleen Strainers Ltd
British Filters Ltd
Boby & Co Ltd, William
British Steam Specialities Ltd
Candy Filter Co Ltd, The
Carlson Ltd, John C.
Colborne Engineering Co Ltd, The
Davey, Paxman & Co Ltd
Doulton Industrial Porcelains Ltd
Endecotts (Filters) Ltd
Fairey Aviation Co Ltd, The
Glenfield & Kennedy Ltd
Heat Transfer Ltd
Hindle & Sons Ltd, Joshua (strainers)
Innes & Co (Darlington) Ltd
Liquid Systems Ltd
Madan & Co Ltd, Charles S.
Marston Excelsior Ltd
Metal & Plastic Compacts Ltd
Nuclear Engineering Ltd
Plenty & Son Ltd
Pulsometer Engineering Co Ltd, The
Simmonds Aerocessories Ltd
Sintered Products Ltd
Thompson-Kennicott Ltd, John

FIRE FIGHTING EQUIPMENT
★ Circle *No 319* on reply card
Angus & Co Ltd, George
BTR Industries Ltd
Coventry Climax Engines Ltd
Fire Armour Ltd
Glenfield & Kennedy Ltd
Hall & Co Ltd, Matthew
Hindle & Sons Ltd, Joshua
Kidde Co Ltd, The Walter
Merryweather & Sons Ltd
Minerva Detector Co Ltd (detectors)
National Fire Protection Co Ltd, The
Nu-Swift Ltd
Pyrene Co Ltd, The
RFD Co Ltd
Sigmund Pumps Ltd

FLEXIBLE PIPING & PIPE JOINTS (*See Pipes & Piping*)

FLOTATION PLANT
★ Circle *No 320* on reply card
Aerox Ltd
Davey, Paxman & Co Ltd
General Electric Co Ltd, The
General Steel Group
Heat Transfer Ltd
Simmons & Hawker Ltd

FRICTION LININGS
★ Circle *No 321* on reply card
Ferodo Ltd

FUEL ELEMENT HANDLING EQUIPMENT
★ Circle *No 322* on reply card
Babcock & Wilcox Ltd
Blundell & Crompton Ltd
Chatwood-Milner Ltd
Clarke, Chapman & Co Ltd
Cravens Ltd
Electro-Hydraulics Ltd
English Electric Co Ltd, The
Evans & Son (Portsmouth) Ltd, J.
Flight Refuelling Ltd
General Electric Co Ltd, The
Hall & Co Ltd, Matthew
Hawker Siddeley Nuclear Power Co Ltd
Horseley Bridge & Thomas Piggott Ltd (castings only)
Humphreys & Glasgow Ltd
Matterson Ltd
Mendip (Chem. Eng.) Ltd (non-metallic)
Monitor Patent Safety Devices Ltd
Palatine Tool & Engineering Co (Surbiton) Ltd
Paterson Hughes Engineering Co Ltd
Rolls-Royce Ltd
Savage & Parsons Ltd
Screw Machine Products Ltd (components)
Shandon Scientific Co Ltd
Spembly Ltd
Strachan & Henshaw, Ltd
Thompson Ordnance Co, John
Western Detail Mfrs Ltd

FUEL ELEMENT MANUFACTURING PLANT
★ Circle *No 323* on reply card
Farmer Norton & Co Ltd, Sir James
Robertson & Co Ltd, W. H. A. (rod and tube extrusion)
TI Nuclear Engineering Ltd (rolling mill)

FUEL ELEMENT DECANNING PLANT
★ Circle *No 324* on reply card
Evans & Son (Portsmouth) Ltd, J.
Palatine Tool & Engineering Co (Surbiton) Ltd
Western Detail Mfrs Ltd

FUME HOODS
★ Circle *No 325* on reply card
Aerospray Associated Ltd
Air Control Installations Ltd
Birmingham & Blackburn Construction Co Ltd
Bullows & Sons Ltd, Alfred
Butterfield Ltd, W. P.
Controlled Heat & Air Ltd
Cyenet Joinery Ltd
Extrudex Ltd
Freeman, Taylor Machines Ltd
Griffin & George Ltd
Hargreaves & Sons Ltd, Henry
Hathernware Ltd
Hoyt Metal Co of Great Britain Ltd, The
Keith Blackman Ltd
Marine & Industrial Plastics Ltd

FUME HOODS—*continued*
Mathews & Yates Ltd
Mendip (Chemical Engineering) Ltd
Opperman Ltd, S. E.
Owen Power Plant Co
Ozonair Engineering Co Ltd
Permali Ltd
Rediweld Ltd
Scientific Furnishings Ltd
Sturtevant Engineering Co Ltd
Supervents Ltd
Thermoplastics Ltd
Tilghman's Ltd
Tupholme & Co Ltd, George E.
Visco Engineering Co Ltd
Weatherfoil Heating Systems Ltd

FURNACES—ARC
★ Circle *No 326* on reply card
AEW Ltd
ASEA Electric Ltd
Birlec-Efco (Melting) Ltd
Fleischmann (London) Ltd
GWB Furnaces Ltd
Head Wrightson Processes Ltd
Leybold Vacuum Sales Ltd
Metalectric Furnaces Ltd
Vacuum Industrial Applications Ltd
Western Detail Mfrs Ltd
Wild-Barfield Electric Furnaces Ltd

FURNACES—INDUCTION
★ Circle *No 327* on reply card
AEW Ltd
ASEA Electric Ltd
Birlec-Efco (Melting) Ltd
Delapena & Son Ltd
Electric Furnace Co Ltd
Fleischmann (London) Ltd
General Electric Co Ltd, The
GWB Furnaces Ltd
Leybold Vacuum Sales Ltd
Metalectric Furnaces Ltd
Metropolitan-Vickers Electrical Co Ltd
Vacuum Industrial Applications Ltd
Western Detail Mfrs Ltd
Wild-Barfield Electric Furnaces Ltd

FURNACES—REDUCTION
★ Circle *No 328* on reply card
Barlow-Whitney Ltd
GWB Furnaces Ltd
Royce Electric Furnaces Ltd
Western Detail Mfrs Ltd

FURNACES—RESISTANCE
★ Circle *No 329* on reply card
AEW Ltd
Barlow-Whitney Ltd
Birlec Ltd
Catterson-Smith Ltd, R. M.
Electric Furnace Co Ltd
General Electric Co Ltd, The
GWB Furnaces Ltd
Hoyt Metal Co of Great Britain Ltd, The
Incandescent Heat Co Ltd
Leybold Vacuum Sales Ltd
Metalectric Furnaces Ltd
Metropolitan-Vickers Electrical Co Ltd
Royce Electric Furnaces Ltd
Spembly Ltd
Vacuum Industrial Applications Ltd
Western Detail Mfrs Ltd
Wild-Barfield Electric Furnaces Ltd

FURNACES—SINTERING
★ Circle *No 330* on reply card
AEW Ltd
Birlec Ltd
Catterson-Smith Ltd, R. M.
GWB Furnaces Ltd
Incandescent Heat Co Ltd
Leybold Vacuum Sales Ltd
Metropolitan-Vickers Electrical Co Ltd
Royce Electric Furnaces Ltd
Spembly Ltd
Vacuum Industrial Applications Ltd
Western Detail Mfrs Ltd

FURNACES—VACUUM
★ Circle *No 331* on reply card
AEW Ltd
Birlec Ltd
Birwelco Ltd
Butterfield Ltd, W. P.
Edwards High Vacuum Ltd
Electric Furnace Co Ltd
Fleischmann (London) Ltd
Leybold Vacuum Sales Ltd
Metropolitan-Vickers Electrical Co Ltd
NGN Electrical Ltd
Pulsometer Engineering Co Ltd
Royce Electric Furnaces Ltd
Spembly Ltd
Vacuum Industrial Applications Ltd
Western Detail Mfrs Ltd

FUSES & FUSEGEAR
★ Circle *No 332* on reply card
ASEA Electric Ltd
British Insulated Callender's Cables Ltd
Donovan Electrical Co Ltd
English Electric Co Ltd, The
General Electric Co Ltd, The
Henley's Telegraph Works Co Ltd, W. T.
Midland Electrical Mfg Co Ltd
Ottermill Switchgear Ltd
Reyrolle & Co Ltd, A.
Siemens Edison Swan Ltd
Simplex Electric Co Ltd
Tube Investments Ltd

GANTRIES
★ Circle *No 333* on reply card
Andrews & Platt (Engineers) Ltd
Blundell & Crompton Ltd
British Industrial Engineering Co (Staffs) Ltd
Fellows Bros Ltd
General Steel Group
Horseley Bridge & Thomas Piggott Ltd

GANTRIES—*continued*
Morris Ltd, Herbert
Motherwell Bridge & Engineering Co Ltd, The
Rye-Arc Ltd
Simon-Carves Ltd
Stokes Taylor & Shaw Ltd
Vaughan Crane Co Ltd
Wharton Crane & Hoist Co Ltd, The

GAS CLEANING PLANT
★ Circle *No 334* on reply card
Aerox Ltd
Air Control Installations Ltd
Doulton Laboratory Porcelains Ltd
Hall & Co Ltd, Matthew
Howden & Co Ltd, James
Humphreys & Glasgow Ltd
Keith Blackman Ltd
Kestner Evaporator & Engineering Co Ltd
Lloyd & Ross Ltd
Mancuna Engineering Ltd
Newton, Chambers & Co Ltd
Power-Gas Corporation Ltd
Q.V.F. Ltd
Simon-Carves Ltd
Stanfield & Carver Ltd
Sturtevant Engineering Co Ltd
Walker Ltd, C. & W.
Western Detail Mfrs Ltd

GAS DRIERS
★ Circle *No 335* on reply card
Heat Transfer Ltd
Incandescent Heat Co Ltd
Kestner Evaporator & Engineering Co Ltd
Lloyd & Ross Ltd
Magnetic Equipment Co Ltd, The
Palatine Tool & Engineering Co (Surbiton) Ltd
QVF Ltd
Western Detail Mfrs Ltd

GAS STORAGE PLANT
★ Circle *No 336* on reply card
Butterfield Ltd, W. P.
Hall & Co Ltd, Matthew
Lloyd & Ross Ltd
Motherwell Bridge & Engineering Co Ltd
Newton, Chambers & Co Ltd
Walker Ltd, C. & W.

GASES—ARGON
★ Circle *No 337* on reply card
British Oxygen Co Ltd, The
Imperial Chemical Industries Ltd
Saturn Oxygen Co Ltd

GASES—CARBON DIOXIDE
★ Circle *No 338* on reply card
Carbon Dioxide Company, The
Imperial Chemical Industries Ltd

GASES—HELIUM
★ Circle *No 339* on reply card
British Oxygen Co Ltd, The

GASES—HYDROGEN
★ Circle *No 340* on reply card
British Oxygen Co Ltd, The
Imperial Chemical Industries Ltd

GASES—NITROGEN
★ Circle *No 341* on reply card
British Oxygen Co Ltd, The

GASES—OXYGEN
★ Circle *No 342* on reply card
British Oxygen Co Ltd, The
Saturn Oxygen Co Ltd
Siebe, Gorman & Co Ltd

GASKETS—PRESSURE VESSEL & PIPE
★ Circle *No 343* on reply card
Beakbane Ltd, Henry
BTR Industries Ltd
Kirk & Co (Tubes) Ltd
Laboratory Apparatus & Glass Blowing Co
QVF Ltd
Ryder & Co (Manchester) Ltd, Thomas
TI Nuclear Engineering Ltd
Turner Bros Asbestos Co Ltd
Walker & Co Ltd, James
Wood Bros & Co (Gaskets) Ltd

GEARING
★ Circle *No 344* on reply card
British Thomson-Houston Co Ltd, The
Brown Corporation Ltd, David
Crofts (Engineers) Ltd
Electropower Gears Ltd
Geartight Unions Ltd
Highfield Gear & Engineering Co Ltd
Meadows Ltd, Henry
Opperman Gears Ltd
Reliance Gear & Engineering Co (Salford) Ltd
Sanderson Bros & Newbould Ltd
Sealey Engineering Co Ltd
Varatio-Strateline Gears Ltd
Weyers Bros Ltd

GENERATORS—a.c.
★ Circle *No 345* on reply card
British Thomson-Houston Co Ltd, The
Crompton Parkinson Ltd
Electric Construction Co Ltd, The
English Electric Co Ltd, The
General Electric Co Ltd, The
Harland Engineering Co Ltd
Harland & Wolff Ltd
Lancashire Dynamo & Crypto Ltd
Lancashire Dynamo Electronic Products Ltd
Laurence, Scott & Electromotors Ltd
Meadows Ltd, Henry
Metropolitan-Vickers Electrical Co Ltd
Parsons & Co Ltd, C. A.
Sykes Ltd, Henry

GENERATORS—d.c.
★ Circle *No 346* on reply card
British Thomson-Houston Co Ltd, The
Crompton Parkinson Ltd

GENERATORS—d.c.—*continued*
Electric Construction Co Ltd, The
English Electric Co Ltd, The
General Electric Co Ltd, The
Harland Engineering Co Ltd
Harland & Wolff Ltd
Lancashire Dynamo & Crypto Ltd
Lancashire Dynamo Electronic Products Ltd
Laurence, Scott & Electromotors Ltd
Metropolitan-Vickers Electrical Co Ltd
Parsons & Co Ltd, C. A.
Sykes Ltd, Henry

GENERATORS—HOMOPOLAR
★ Circle *No 347* on reply card
British Thomson-Houston Co Ltd, The
Metropolitan-Vickers Electrical Co Ltd
Palatine Tool & Engineering Co (Surbiton) Ltd

GENERATORS—VARIABLE FREQUENCY
★ Circle *No 348* on reply card
British Thomson-Houston Co Ltd, The
Crompton Parkinson Ltd
Elliott Bros (London) Ltd
English Electric Co Ltd, The
Harland Engineering Co Ltd
Lancashire Dynamo Electronic Products Ltd
Metropolitan-Vickers Electrical Co Ltd

GOVERNORS—GAS
★ Circle *No 349* on reply card
Berk & Co Ltd, F. W. (Schori Division)
British Oxygen Co Ltd
Bryan Donkin Co Ltd, The
Cockburns Ltd
Crosby Valve & Engineering Co Ltd
Elliott Bros (London) Ltd
Fisher Governor Co Ltd
Kent Ltd, George
Reavell & Co Ltd
Ruston & Hornsby Ltd
Thermocontrol Installations Ltd
Wright & Co Ltd, Alexander

GOVERNORS—TURBINE
★ Circle *No 350* on reply card
Ardleigh Engineering Ltd
Ashworth & Parker Ltd
British Thomson-Houston Co Ltd, The
Cockburns Ltd
Davey, Paxman & Co Ltd
English Electric Co Ltd, The
General Electric Co Ltd, The
Metropolitan-Vickers Electrical Co Ltd
Nuclear Power Plant Co Ltd
Ruston & Hornsby Ltd

GRANULATORS
★ Circle *No 351* on reply card
Allen & Co Ltd, Edgar
Apex Construction Ltd
Manesty Machines Ltd
Mansfield & Co Ltd, Frank

GRAPHITE—DISPERSIONS
★ Circle *No 352* on reply card
Acheson Colloids Ltd
British Acheson Electrodes Ltd
Centralube Ltd

GRAPHITE—MODERATOR
★ Circle *No 353* on reply card
Anglo Great Lakes Corporation Ltd
British Acheson Electrodes Ltd
English Electric Co Ltd, The
Morgan Crucible Co Ltd, The
Nuclear Graphite Ltd
Powell Duffryn Carbon Products Ltd

GRAPHITE—REFLECTOR
★ Circle *No 354* on reply card
Anglo Great Lakes Corporation Ltd
British Acheson Electrodes Ltd
English Electric Co Ltd, The
Nuclear Graphite Ltd
Powell Duffryn Carbon Products Ltd

GRINDING EQUIPMENT
★ Circle *No 355* on reply card
Anglo Abrasives Ltd
Flextol Engineering Co Ltd
Neill & Co (Sheffield) Ltd, James
Norton Grinding Wheel Co Ltd
Ross & Partners Ltd, Donald
Saturn Industrial Gases Ltd
Turret Grinding Wheel Co Ltd

HEAT EXCHANGERS—GAS/GAS
★ Circle *No 356* on reply card
Adamson & Co Ltd, Daniel
Aiton & Co Ltd
APV Co Ltd, The
Ashmore, Benson, Pease & Co
Babcock & Wilcox Ltd
Balfour & Co Ltd, Henry
Bennett Sons & Shears Ltd
Birwelco Ltd
Blundell & Crompton Ltd
Brown Fintube (GB) Ltd
Butterfield Ltd, W. P.
Capper & Co Ltd, William H.
Chesterfield Tube Co Ltd, The
Clarke, Chapman & Co Ltd
Davey, Paxman & Co Ltd
Foster Wheeler Ltd
Foster, Yates & Thom Ltd
Fraser & Co Ltd, W. J.
Freeman, Taylor Machines Ltd
General Electric Co Ltd, The
Green & Son Ltd, E.
Harris (Birmingham) Ltd, F. & R. M.
Hawker Siddeley Nuclear Power Co Ltd
Head Wrightson & Co Ltd (Nuclear Power Div)
Head Wrightson Processes Ltd
Heat Exchangers Ltd
Heat Transfer Ltd
Horseley Bridge & Engineering Co Ltd, The
Howden & Co Ltd, James
Kestner Evaporator & Engineering Co Ltd, The

HEAT EXCHANGERS—GAS—*continued*
Lloyd & Ross Ltd
Marston Excelsior Ltd
Metropolitan-Vickers Electrical Co Ltd
Morgan Crucible Co Ltd, The
Newton, Chambers & Co Ltd
New Metals & Chemicals Ltd
Nuclear Engineering Ltd
Premier Cooler & Engineering Co Ltd, The
QVF Ltd
Rolls-Royce Ltd
Ruston & Hornsby Ltd
Ryder & Co (Manchester) Ltd, Thomas
Serck Radiators Ltd
Simmons & Hawker Ltd
Simon-Carves Ltd
Spiral Tube & Components Co Ltd
Spiro-Gills Ltd
Stainless Steel Vessels (London) Ltd
Superheater Co Ltd, The
Thermocontrol Installations Co Ltd
Thompson Water Tube Boilers Ltd, John
TI Nuclear Engineering Ltd
Unit Superheater & Pipe Co Ltd
Walker Ltd, C. & W.
Wellington Tube Works Ltd
Wilmot Breeden Ltd
Western Detail Mfrs Ltd
Yarrow & Co Ltd

HEAT EXCHANGERS—GAS/METAL
★ Circle *No 357* on reply card
APV Co Ltd, The
Babcock & Wilcox Ltd
Birwelco Ltd
Brown Fintube (GB) Ltd
Clarke, Chapman & Co Ltd
Davey, Paxman & Co Ltd
Electro-Hydraulics Ltd
Foster Wheeler Ltd
Foster, Yates & Thom Ltd
Fraser & Co Ltd, W. J.
General Electric Co Ltd, The
Hawker Siddeley Nuclear Power Co Ltd
Head Wrightson Processes Ltd
Heat Exchangers Ltd
Heat Transfer Ltd
Marston Excelsior Ltd
Morgan Crucible Co Ltd, The
Nuclear Engineering Ltd
Rolls-Royce Ltd
Ryder & Co (Manchester) Ltd, Thomas
Serck Radiators Ltd
Simon-Carves Ltd
Spiral Tube & Components Co Ltd
Stainless Steel Vessels (London) Ltd
Superheater Co Ltd, The
Thompson Water Tube Boilers Ltd, John
TI Nuclear Engineering Ltd
Wellington Tube Works Ltd
Western Detail Mfrs Ltd

HEAT EXCHANGERS—GAS/WATER
★ Circle *No 358* on reply card
Aiton & Co Ltd
APV Co Ltd, The
Ashmore, Benson, Pease & Co
Babcock & Wilcox Ltd
Birwelco Ltd
Blundell & Crompton Ltd
Brown Fintube (GB) Ltd
Butterfield Ltd, W. P.
Capper & Co Ltd, William H.
Clarke, Chapman & Co Ltd
Davey, Paxman & Co Ltd
Foster Wheeler Ltd
Foster, Yates & Thom Ltd
Fraser & Co Ltd, W. J.
Freeman, Taylor Machines Ltd
General Electric Co Ltd, The
Green & Son Ltd, E.
Hawker Siddeley Nuclear Power Co Ltd
Head Wrightson & Co Ltd (Nuclear Power Div)
Head Wrightson Processes Ltd
Heat Exchangers Ltd
Heat Transfer Ltd
Horseley Bridge & Thomas Piggott Ltd
International Combustion Ltd
Jenkins & Co Ltd, Robert
Johnstone (Engineers) Ltd, Archibald
Kestner Evaporator & Engineering Co Ltd
Marston Excelsior Ltd
Metal Propellers Ltd
Metropolitan-Vickers Electrical Co Ltd
Morgan Crucible Co Ltd, The
Nuclear Engineering Ltd
Nuclear Power Plant Co Ltd, The
Newton, Chambers & Co Ltd
QVF Ltd
Ruston & Hornsby Ltd
Ryder & Co (Manchester) Ltd, Thomas
Serck Radiators Ltd
Simmons & Hawker Ltd
Simon-Carves Ltd
Spiral Tube & Components Co Ltd
Spiro-Gills Ltd
Stainless Steel Vessels (London) Ltd
Stanfield & Carver Ltd
Superheater Co Ltd, The
Thompson Water Tube Boilers Ltd, John
TI Nuclear Engineering Ltd
Unit Superheater & Pipe Co Ltd
Weir Ltd, G. & J.
Wellington Tube Works Ltd
Western Detail Mfrs Ltd
Whittaker Hall & Co (1929) Ltd

HEAT EXCHANGERS—METAL/METAL
★ Circle *No 359* on reply card
APV Co Ltd, The
Babcock & Wilcox Ltd
Birwelco Ltd
Brown Fintube (GB) Ltd
Davey, Paxman & Co Ltd
Foster Wheeler Ltd
Foster, Yates & Thom Ltd
Fraser & Co Ltd, W. J.
General Electric Co Ltd, The
Hawker Siddeley Nuclear Power Co Ltd
Head Wrightson Processes Ltd

HEAT EXHANGERS—METAL/METAL
—*continued*
Heat Exchangers Ltd
Heat Transfer Ltd
Marston Excelsior Ltd
Morgan Crucible Co Ltd, The
Nuclear Engineering Ltd
Palatine Tool & Engineering Co (Surbiton) Ltd
Ryder & Co (Manchester) Ltd, Thomas
Rolls Royce Ltd
Simon-Carves Ltd
Spiral Tube & Components Co Ltd
Stainless Steel Vessels (London) Ltd
Superheater Co Ltd, The
Thompson Water Tube Boilers Ltd, John
TI Nuclear Engineering Ltd
Wellington Tube Works Ltd
Western Detail Mfrs Ltd

HEAT EXCHANGERS—METAL/WATER
★ Circle *No 360* on reply card
APV Co Ltd, The
Babcock & Wilcox Ltd
Birwelco Ltd
Brown Fintube (GB) Ltd
Davey, Paxman & Co Ltd
Electro-Hydraulics Ltd
Fenton, Bryn & Co Ltd
Foster Wheeler Ltd
Foster, Yates & Thom Ltd
Fraser & Co Ltd, W. J.
General Electric Co Ltd, The
Hawker Siddeley Nuclear Power Co Ltd
Head Wrightson Processes Ltd
Heat Exchangers Ltd
Heat Transfer Ltd
Marston Excelsior Ltd
Morgan Crucible Co Ltd, The
Newton, Chambers & Co Ltd
Nuclear Engineering Ltd
Ryder & Co (Manchester) Ltd, Thomas
Simon-Carves Ltd
Spiral Tube & Components Co Ltd
Stainless Steel Vessels (London) Ltd
Standard & Pochin Bros Ltd, The
Superheater Co Ltd, The
Thompson Water Tube Boilers Ltd, John
TI Nuclear Engineering Ltd
Wellington Tube Works Ltd
Western Detail Mfrs Ltd

HEAT EXCHANGERS—WATER/WATER
☆ Circle *No 361* on reply card
Aiton & Co Ltd
APV Co Ltd, The
Ashmore, Benson, Pease & Co
Babcock & Wilcox Ltd
Birwelco Ltd
Blundell & Crompton Ltd
Brown Fintube (GB) Ltd
Butterfield Ltd, W. P.
Capper & Co Ltd, William H.
Clarke, Chapman & Co Ltd
Davey, Paxman & Co Ltd
Foster Wheeler Ltd
Foster, Yates & Thom Ltd
Fraser & Co Ltd, W. J.
Freeman, Taylor Machines Ltd
General Electric Co Ltd, The
Green & Son Ltd, E.
Hawker Siddeley Nuclear Power Co Ltd
Head Wrightson & Co Ltd (Nuclear Power Div)
Head Wrightson Processes Ltd
Heat Exchangers Ltd
Heat Transfer Ltd
Horseley Bridge & Thomas Piggott Ltd
Jenkins & Co Ltd, Robert
Kestner Evaporator and Engineering Co Ltd
Marston Excelsior Ltd
Metal Propellers Ltd
Metropolitan-Vickers Electrical Co Ltd
Mills Packard Construction Co Ltd
Morgan Crucible Co Ltd, The
Newton, Chambers & Co Ltd
Nuclear Engineering Ltd
QVF Ltd
Richardsons, Westgarth & Co Ltd
Ruston & Hornsby Ltd
Ryder & Co (Manchester) Ltd, Thomas
Serck Radiators Ltd
Simmons & Hawker Ltd
Simon-Carves Ltd
Spiral Tube & Components Co Ltd
Spiro-Gills Ltd
Superheater Co Ltd, The
Stanfield & Carver Ltd
Stainless Steel Vessels (London) Ltd
Thompson Water Tube Boilers Ltd, John
TI Nuclear Engineering Ltd
Weir Ltd, G. & J.
Wellington Tube Works Ltd
Western Detail Mfrs Ltd
Worthington-Simpson Ltd

HEATERS—PIPE
★ Circle *No 362* on reply card
APV Co Ltd, The
Backer Electrical Co Ltd (bolt heaters etc.)
Isopad Ltd
Stabilag Co Ltd, The
Walker Ltd, C. & W.

HYDRAULIC CONTROL EQUIPMENT
★ Circle *No 363* on reply card
Avica Equipment Ltd
Baldwin Instrument Co Ltd
Boulton Paul Aircraft Ltd
Chamberlain Industries Ltd
Dowty Nucleonics Ltd
Elliott Brothers (London) Ltd
Ellison Ltd, George
Evans & Son (Portsmouth) Ltd, J.
Exactol Ltd
Fairey Aviation Co Ltd, The
Fraser & Co Ltd, Andrew
Gordon & Co Ltd, James
Hamworthy Engineering Ltd
Hobson Ltd, H. M.
Hindle & Sons Ltd, Joshua
Keelavite Hydraulics Ltd

HYDRAULIC CONTROL EQUIPMENT
—*continued*
Integral Ltd
Martonair Ltd
Muirhead & Co Ltd
Philips Electrical Ltd
Plessey Co Ltd, The
Robey & Co Ltd
Tangyes Ltd
Thermocontrol Installations Co Ltd
Towler Bros (Patents) Ltd
Vickers-Armstrongs (Engineers) Ltd
Weyers Bros Ltd

INSTRUMENTATION SYSTEMS (*See Contractors —Instrumentation*)

INSULATION—THERMAL
★ Circle *No 364* on reply card
British Refrasil Co Ltd, The
BX Plastics Ltd
Cape Asbestos Co Ltd
Darlington Insulation Co Ltd, The
Expanded Plastics Ltd
Extrudex Ltd
Fibreglass Ltd
General Refractories Ltd
Hargreaves & Sons Ltd, Henry
Kenyon & Sons Ltd, Wm.
Leybold Vacuum Sales Ltd
Mallinson & Sons Ltd, William
Mansfield & Co Ltd, Frank
Moler Products Ltd
Morgan Crucible Co Ltd, The
Morgan Refractories Ltd
Munro & Miller Ltd
Newalls Insulation Co Ltd
Northern Insulation Co (Stockton) Ltd
Onazote Insulation Co Ltd
Pilkington Bros Ltd
Simon-Carves Ltd
Stabilag Co Ltd
Stillite Products Ltd
Turner Bros Asbestos Co Ltd

INSULATORS—ELECTRICAL
★ Circle *No 365* on reply card
British Insulated Callender's Cables Ltd
BX Plastics Ltd
Darlington Insulation Co Ltd, The
Doulton Industrial Porcelains Ltd
English Electric Co Ltd, The
General Electric Co Ltd, The
Hellermann Ltd
Lodge Plugs Ltd
Micanite & Insulators Co Ltd, The
National Plastics Ltd
Pilkington Bros Ltd
Permali Ltd
Siemens Edison Swan Ltd
Steatite & Porcelain Products Ltd

INSURANCE & INSPECTION
☆ Circle *No 366* on reply card
Evers, David H.
Lloyd's Register of Shipping (Land Division)
National Boiler & General Insurance Co Ltd, The
Vulcan Boiler & General Insurance Co Ltd

ION EXCHANGE PLANT
★ Circle *No 367* on reply card
Chatwood-Milner Ltd
Colborne Engineering Co Ltd, The
Crosfield & Sons Ltd, Joseph
Boby & Co Ltd, William
Griffin & George Ltd
Permutit Co Ltd, The
QVF Ltd
Thompson-Kennicott Ltd, John

ISOTOPE PRODUCTION EQUIPMENT
★ Circle *No 368* on reply card
Nuclear Engineering Ltd
QVF Ltd
Research & Control Instruments Ltd

JOINTING MATERIAL
★ Circle *No 369* on reply card
Barytes (Shielding Products) Ltd
British Steam Specialities Ltd
Expandite Ltd
Klinger Ltd, Richard
Mastabar Mining Equipment Ltd
Turner Bros Asbestos Ltd
Walker & Co Ltd, James
Wood Bros & Co (Gaskets) Ltd

LEAD
★ Circle *No 370* on reply card
Appleton & Howard Ltd (castings)
Associated Lead Mfrs Ltd (all forms)
British Lead Mills Ltd (all forms)
Grazebrook Ltd, M. & W. (linings)
Grey & Marten Ltd (Sheet, blocks)
Mills Packard Construction Co Ltd (blocks, fabrications of all types)
Podmore & Sons Ltd, W. (silicates & aluminates)
Research & Control Instruments Ltd
Savage & Parsons Ltd (blocks)

LIFTING GEAR
★ Circle *No 371* on reply card
Andrews & Platt (Engineers) Ltd
Carruthers & Co Ltd, J. H.
Caswell Cranes & Erection Ltd
Clayton Crane & Hoist Co Ltd
Felco Hoists Ltd
Fellows Bros Ltd
General Steel Group
Globe Pneumatic Eng Co Ltd
Henderson & Co Ltd, John M.
Matterson Ltd
Mitchell Engineering Ltd
Moore Ltd, W. & E.
Morris Ltd, Herbert
Paterson Hughes Engineering Co Ltd
Steels Engineering Products Ltd
Sykes Ltd, Henry
Tangyes Ltd
Vaughan Crane Co Ltd, The
Wharton Crane & Hoist Co Ltd, The

LIGHTING EQUIPMENT
★ Circle *No 372* on reply card
AEI Lamps & Lighting Co Ltd
Allen & Co, P. W.
Andrews & Platt (Engineers) Ltd
Bailey & Co Ltd, N. G.
Belmos Co Ltd, The
Clarke, Chapman & Co Ltd
CWC Equipment Ltd
General Electric Co Ltd, The
Petbow Ltd
Siemens Edison Swan Ltd
Simplex Electric Co Ltd
Victor Products (Wallsend) Ltd

LUBRICANTS
★ Circle *No 373* on reply card
Acheson Colloids Ltd
Midland Silicones Ltd
Paul (Molybdenum Disulphide) Ltd, K. S.
Rocol Ltd
Shell-Mex & BP Ltd
Wakefield-Dick Industrial Oils Ltd

LUBRICATION EQUIPMENT
★ Circle *No 374* on reply card
Centralube Ltd
Clarke, Chapman & Co Ltd
Liquid Systems Ltd
Norgren Ltd, C. A.
Sharples Centrifuges Ltd
Wakefield-Dick Industrial Oils Ltd
Vokes Ltd (Filters)

MACHINE TOOLS—FOR FUEL ELEMENT MFG
★ Circle *No 375* on reply card
Adam Machine Equipment Ltd
Adcock & Shipley Ltd
Carne & Co Ltd, Rudolph
Craven Bros (Manchester) Ltd
Hardinge Machine Tools Ltd
Electro-Hydraulics Ltd
EMI Electronics Ltd
Evans & Son (Portsmouth) Ltd

MACHINE TOOLS—FOR GRAPHITE BLOCK MFG
★ Circle *No 376* on reply card
Adcock & Shipley Ltd
Caine & Co Ltd, Rudolph
Hardinge Machine Tools Ltd
Morrison, Marshall & Hill Ltd (Bandsaws)
Wicksteed & Co (1920) Ltd, Charles

MAGNETIC CRACK DETECTION EQUIPMENT
★ Circle *No 377* on reply card
Metropolitan-Vickers Electrical Co Ltd
Welding Supplies Ltd

MECHANICAL HANDLING EQUIPMENT
★ Circle *No 378* on reply card
Aerox Ltd
Allen & Sons (Tipton) Ltd, W. G.
Andrews & Platt (Engineers) Ltd
Ayling Nuclear Equipment Co
Babcock & Wilcox Ltd
Birmingham & Blackburn Construction Co Ltd
Birtley Engineering Ltd
British Industrial Engineering Co (Staffs) Ltd
BTR Industries Ltd
Caswell Cranes & Erection Ltd
Chamberlain Industries Ltd
Clarke, Chapman & Co Ltd
Conveyancer Fork Trucks Ltd
Coventry Climax Engines Ltd
Crofts (Engineers) Ltd
Dexion Ltd
Electro-Hydraulics Ltd
Fellows Bros Ltd
Fisher & Ludlow Ltd
Fowler & Co (Leeds) Ltd, John
General Electric Co Ltd, The
General Steel Group
Globe Pneumatic Eng Co Ltd
Hall & Co Ltd, Matthew
Henderson & Co Ltd, John M.
Hobson Ltd, H. M.
I.T.D. Ltd
Leverstat Ltd (battery trucks)
Lloyd & Ross Ltd
Magnetic Equipment Co Ltd, The
Manufacturers Equipment Co Ltd
Marine & Industrial Plastics Ltd
Matterson Ltd
Mitchell Engineering Ltd
Moore & Co Ltd, W. & E.
Morris Ltd, Herbert
Morrison, Marshall & Hill Ltd
Motherwell Bridge & Engineering Co Ltd, The
Palatine Tool & Engineering Co (Surbiton) Ltd
Parker Mitchell Engineering Co Ltd
Paterson Hughes Engineering Co Ltd
Ramsey Engineering Co Ltd
Renold Chains Ltd
Simon-Carves Ltd
Steels Engineering Products Ltd
Strachan & Henshaw Ltd
Teleflex Products Ltd
Thompson Conveyor Co, John
Ward Ltd, Thos W.
Western Detail Mfrs Ltd
Wilson & Partners Ltd, A. C.

METALS—ALUMINIUM
★ Circle *No 379* on reply card
Accles & Pollock Ltd (tubes)
Almin Ltd
Berk & Co Ltd, F. W.—Schori Division (powder)
Birmetals Ltd (sheet, tube, wire, rod, bar, sections)
Booth & Co Ltd, James
British Aluminium Co Ltd (all forms)
Eltay Tubes Ltd (tubes)
Gardner & Co Ltd, Henry (all forms)
General Chemical & Pharmaceutical Co Ltd, The
Hawker Siddeley Nuclear Power Co Ltd
High Duty Alloys Ltd
Horseley Bridge & Thomas Piggott Ltd
Imperial Chemical Industries Ltd (all forms)
Imperial Smelting Corporation (Sales) Ltd
Kaye Ltd, E. & E. (bar, tube, rod, wire, extruded sections)
London Aluminium Co Ltd

METALS—ALUMINIUM—*continued*
London Metal Warehouses Ltd (all forms)
Northern Aluminium Co Ltd (sheet, plate, sections, tube, wire, rod, castings, forgings)
Smith & Sons (Clerkenwell) Ltd, J. (bar, sheet, tube, rod)
Southern Forge Ltd
Sterling Metals Ltd
TI Nuclear Engineering Ltd (tube & sheet)

METALS—BERYLLIUM
★ Circle *No 380* on reply card
Gardner & Co Ltd, Henry (all forms)
General Chemical & Pharmaceutical Co Ltd, The
General Electric Co Ltd, The
New Metals & Chemicals Ltd
Telegraph Construction & Maintenance Co Ltd
TI Nuclear Engineering Ltd (tube)

METALS—BORON
★ Circle *No 381* on reply card
Acheson Colloids Ltd
Borax Consolidated Ltd
General Chemical & Pharmaceutical Co Ltd, The
Hadfields Ltd
New Metals & Chemicals Ltd
TI Nuclear Engineering Ltd (tube)

METALS—CADMIUM
★ Circle *No 382* on reply card
Consolidated Zinc Corp (Sales) Ltd (all forms)
Gardner & Co Ltd, Henry (all forms)
General Chemical & Pharmaceutical Co Ltd, The
Johnson, Matthey & Co Ltd
New Metals & Chemicals Ltd

METALS—COPPER
★ Circle *No 383* on reply card
Berk & Co Ltd, F. W.—Schori Division (powder)
Eltay Tubes Ltd (tubes)
Gardner & Co Ltd, Henry (all forms)
General Chemical & Pharmaceutical Co Ltd, The
Grey & Marten Ltd (tube, rod)
Imperial Chemical Industries Ltd (all forms)
Kaye Ltd, E. & E. (wire, strip)
London Metal Warehouses Ltd (all forms)
Mullard Ltd (wire)
Smith & Sons (Clerkenwell) Ltd, J. (bar, sheet, tube, rod)
Telegraph Construction & Maintenance Co Ltd

METALS—HAFNIUM
★ Circle *No 384* on reply card
Bramah & Co Ltd, J. R. (fabrications)
General Chemical & Pharmaceutical Co Ltd, The

METALS—LITHIUM
★ Circle *No 385* on reply card
Gardner & Co Ltd, Henry (all forms)
General Chemical & Pharmaceutical Co Ltd, The
Johnson, Matthey & Co Ltd

METALS—MAGNESIUM
★ Circle *No 386* on reply card
Almin Ltd
Birmetals Ltd (sheet, tube, wire, rod, bar, sections)
Bramah & Co Ltd, J. R. (fabrications)
Gardner & Co Ltd, Henry (all forms)
General Chemical & Pharmaceutical Co Ltd, The
Hawker Siddeley Nuclear Power Co Ltd
High Duty Alloys Ltd
Imperial Chemical Industries Ltd
Magnesium Elektron Ltd
Sterling Metals Ltd
TI Nuclear Engineering Ltd (tube)

METALS—MOLYBDENUM
★ Circle *No 387* on reply card
Accles & Pollock Ltd
Gardner & Co Ltd, Henry (all forms)
General Chemical & Pharmaceutical Co Ltd, The
General Electric Co Ltd, The
Hadfields Ltd
Mullard Ltd (wire)
Murex Ltd (bar, sheet, wire, rod, fabricated parts)
New Metals & Chemicals Ltd
TI Nuclear Engineering Ltd (tube)

METALS—NICKEL
★ Circle *No 388* on reply card
Accles & Pollock Ltd
Gardner & Co Ltd, Henry (all forms)
General Chemical & Pharmaceutical Co Ltd, The
Hadfields Ltd
Horseley Bridge & Thomas Piggott Ltd
Mond Nickel Co Ltd, The
TI Nuclear Engineering Ltd (tube)

METALS—NIOBIUM
★ Circle *No 389* on reply card
Accles & Pollock Ltd (tubes)
Beardmore & Co Ltd, William
Gardner & Co Ltd, Henry (all forms)
General Chemical & Pharmaceutical Co Ltd, The
Imperial Chemical Industries Ltd (all forms)
London & Scandinavian Metallurgical Co Ltd
Murex Ltd (bar, sheet, wire, rod, fabricated parts)
New Metals & Chemicals Ltd
TI Nuclear Engineering Ltd (tube)

METALS—STAINLESS STEEL
★ Circle *No 390* on reply card
Accles & Pollock Ltd (tubes)
Allen & Co Ltd, Edgar (bar & sheet)
APV Co Ltd, The (tubes)
Darwins Ltd
Firth-Vickers Stainless Steels Ltd
Fox & Co Ltd, Samuel
Hadfields Ltd
Jessop & Sons Ltd, William
London Metal Warehouses Ltd
Low Moor Alloy Steelworks Ltd
Mountford (Birmingham) Ltd, Frederick
Oxley & Co Ltd, Wm. (castings, forgings, pipe flanges)
Sanderson Bros & Newbould Ltd
Talbot Stead Tube Co Ltd (tubes & bars)
Taylor Stainless Metals Co Ltd (bar, sections, sheet, strip etc.)

METALS—STAINLESS STEEL—*continued*
TI Nuclear Engineering Ltd (tube)
United Steel Companies Ltd, The (sheets)

METALS—STEEL *(See Steel)*

METALS—TANTALUM
★ Circle *No 391* on reply card
Accles & Pollock Ltd (tubes)
Gardner & Co Ltd, Henry (all forms)
General Chemical & Pharmaceutical Co Ltd, The
London & Scandinavian Metallurgical Co Ltd
Murex Ltd (bar, sheet, wire, rod, fabricated parts)
TI Nuclear Engineering Ltd (tube)

METALS—THORIUM
★ Circle *No 392* on reply card
General Chemical & Pharmaceutical Co Ltd, The
Thorium Ltd
TI Nuclear Engineering Ltd (tube & bar)

METALS—TITANIUM
★ Circle *No 393* on reply card
Accles & Pollock Ltd (tubes)
Bramah & Co Ltd, J. R. (fabrications)
APV Co Ltd, The (pressings)
Gardner & Co Ltd, Henry (all forms)
General Chemical & Pharmaceutical Co Ltd, The
High Duty Alloys Ltd
Imperial Chemical Industries Ltd (all forms)
Jessop & Sons Ltd, William
TI Nuclear Engineering Ltd (tube)
Titanium Metal & Alloys Ltd

METALS—TUNGSTEN
★ Circle *No 394* on reply card
Gardner & Co Ltd, Henry (all forms)
General Chemical & Pharmaceutical Co Ltd, The
General Electric Co Ltd, The
Mullard Ltd (wire & rod)
Murex Ltd (bar, sheet, rod, wire, fabricated parts)

METALS—VANADIUM
★ Circle *No 395* on reply card
Accles & Pollock Ltd (tubes)
Gardner & Co Ltd, Henry (all forms)
General Chemical & Pharmaceutical Co Ltd, The
Magnesium Elektron Ltd
TI Nuclear Engineering Ltd (tube)

METALS—ZIRCONIUM
★ Circle *No 396* on reply card
Accles & Pollock Ltd (tubes)
Bramah & Co Ltd, J. R. (fabrications)
Gardner & Co Ltd, Henry (all forms)
General Chemical & Pharmaceutical Co Ltd, The
Imperial Chemical Industries Ltd (all forms)
Jessop & Sons Ltd, William
Magnesium Elektron Ltd (salts)
Murex Ltd (bar, sheet, wire, rod, fabricated parts
New Metals & Chemicals Ltd
TI Nuclear Engineering Ltd (tube)
Titanium Metal & Alloys Ltd

METALS—OTHERS
★ Circle *No 397* on reply card
Atkinson Ltd, D. & J. M. (mercury)
Berk & Co Ltd, F. W.—Schori Division (zinc powder)
Consolidated Zinc Corp (Sales) Ltd (zinc)
Deloro Stellite Ltd (cobalt & nickel base alloys)
Grey & Marten Ltd (tin, zinc)
Hadfields Ltd (boron alloy steels)
High Duty Alloys (aluminium & magnesium alloys)
Incandescent Heat Co Ltd (nickel-chrome alloys)
Kestner Evaporator & Engineering Co Ltd (silicon iron)
London & Scandinavian Metal Co Ltd (alloys of boron, titanium, niobium, tantalum)
Manganese Bronze & Brass Co Ltd, The
Metal & Plastic Compacts Ltd (ferro-boron alloys)
Scientific Metal Co Ltd (mercury)
Sheffield Smelting Co Ltd, The (silver solders, brazing alloys)
Smith & Sons (Clerkenwell) Ltd, J. (brass, manganese-bronze, phosphor-bronze, aluminium alloys)
Southern Forge Ltd (aluminium alloys)
TI Nuclear Engineering Ltd (ferro-boron)
United Steel Companies Ltd, The (special steel alloys)
Willan Ltd, G. L.

MILLS—ORE REDUCING
★ Circle *No 398* on reply card
Allen & Co Ltd, Edgar
Apex Construction Ltd
Babcock & Wilcox Ltd
Boulton Ltd, Wm
Follsain-Wycliffe Foundries Ltd
General Electric Co Ltd, The
Manesty Machines Ltd
Mansfield & Co Ltd, Frank
Sturtevant Engineering Co Ltd
Wilkinson Rubber Linatex Ltd

MILLS—ROLLING
★ Circle *No 399* on reply card
Armstrong Whitworth (Met. Ind.) Ltd
Brockhouse & Co Ltd, J.
Mann's Engineering Co Ltd, Albert
Marshall Richards Machine Co Ltd
Norton & Co Ltd, Sir James Farmer
Robertson & Co Ltd, W. H. A.
TI Nuclear Engineering Ltd

MIXER-SETTLERS—PULSE
★ Circle *No 400* on reply card
Lang London Ltd

MOTOR GENERATOR SETS
★ Circle *No 401* on reply card
ASEA Electric Ltd
British Thomson-Houston Co Ltd, The
Clarke, Chapman & Co Ltd
Electric Construction Co Ltd, The
English Electric Co Ltd, The

MOTOR GENERATOR SETS—*continued*
General Electric Co Ltd, The
Harland & Wolff Ltd
Lancashire Dynamo & Crypto Ltd
Lincoln Electric Co Ltd
Mather & Platt Ltd
Metropolitan-Vickers Electrical Co Ltd
Napier & Son Ltd, D.
Petbow Ltd
Ruston & Hornsby Ltd
Sykes Ltd, Henry

MOUNTINGS—ANTI-VIBRATION
★ Circle *No 402* on reply card
Fenner & Co Ltd, J. H.
Metalastik Ltd
Precision Rubbers Ltd
Silentbloc Ltd

NUCLEAR POWER STATIONS (*See Contractors —Nuclear Power Station*)

NUCLEAR REACTORS—(*See Reactors & Section 2*)

O-RINGS
★ Circle *No 403* on reply card
Angus & Co Ltd, George
British Ermeto Corporation Ltd
BTR Industries Ltd
Dowty Seals Ltd
Edwards High Vacuum Ltd
Hindle & Sons Ltd, Joshua
Labgear Ltd
Leybold Vacuum Sales Ltd
Pioneer Oilsealing & Moulding Co Ltd
Precision Rubbers Ltd
TI Nuclear Engineering Ltd
Trist & Co Ltd, Ronald
Vacuum Industrial Applications Ltd
Walker & Co Ltd, James

PACKINGS—GLAND
★ Circle *No 404* on reply card
Angus & Co Ltd, George
Beakbane Ltd, Henry
BTR Industries Ltd
Flexibox Ltd
Hindle & Sons Ltd, Joshua
Lorant & Co Ltd
TI Nuclear Engineering Ltd
Trist & Co Ltd, Ronald
Turner Bros Asbestos Co Ltd
United States Metallic Packing Co Ltd
Walker & Co Ltd James
Wood Bros & Co (Gaskets) Ltd

PIPE COUPLINGS
★ Circle *No 405* on reply card
Avimo Ltd
Babcock & Wilcox Ltd
British Ermeto Corporation Ltd
British Steam Specialities Ltd
Capper & Co Ltd, William H.
Guyson Industrial Equipment Ltd
Hindle & Sons Ltd, Joshua
Kirk & Co (Tubes) Ltd
Leybold Vacuum Sales Ltd
Mendip (Chem. Eng.) Ltd
QVF Ltd
Ryder & Co (Manchester) Ltd, Thomas
Simmons & Hawker Ltd
Spembly Ltd
Stewarts & Lloyds Ltd
Sykes Ltd, Henry
Talbot Stead Tube Co Ltd
TI Nuclear Engineering Ltd
Walker Ltd, C. & W.

PIPE EXPANSION JOINTS
★ Circle *No 406* on reply card
Aiton & Co Ltd
Avica Equipment Ltd (bellows)
Babcock & Wilcox Ltd (all types)
Blundell & Crompton Ltd (bellows & sleeve)
British Steam Specialities Ltd (sliding type)
Capper & Co Ltd, William H. (bellows)
Clarke, Chapman & Co Ltd (bellows)
Crane Packing Ltd
Engineering Appliances Ltd (bellows)
Extrudex Ltd
IV Pressure Controllers Ltd (bellows)
Jenkins & Co Ltd, Robert (all types)
Kirk & Co (Tubes) Ltd (all types)
Munro & Miller Ltd (bellows)
Nuclear Power Plant Co Ltd, The
Palatine Tool & Engineering Co (Surbiton) Ltd (bellows)
Power Flexible Tubing Co Ltd, The (bellows)
Press & Son Ltd, William (bellows)
QVF Ltd (bellows)
Rye-Arc Ltd
Simmons & Hawker Ltd (bellows, gland, loop)
Shaw Glasgow Ltd
Shaw-Petrie Ltd
Simon-Carves Ltd
Stewarts & Lloyds Ltd (all types)
Teddington Aircraft Controls Ltd (bellows)
TI Nuclear Engineering Ltd (bellows)
Unit Superheater & Pipe Co Ltd (bellows)
Walker Ltd, C. & W.

PIPE FITTINGS—WELDING
★ Circle *No 407* on reply card
Babcock & Wilcox Ltd
BKL Alloys Ltd
Blundell & Crompton Ltd
British Ermeto Ltd
British Steam Specialities Ltd
Capper & Co Ltd, William H.
Compoflex Co Ltd
High Pressure Components Ltd
Hindle & Sons Ltd, Joshua
Hopkins & Co Ltd, F.
Imperial Chemical Industries Ltd
Kirk & Co (tubes) Ltd
Munro & Miller Ltd
Osborne & Co Ltd, S.
Press & Son Ltd, William
Rediweld Ltd
Ryder & Co (Manchester) Ltd, Thomas

PIPE FITTINGS—WELDING—*continued*
Shaw & McInnes Ltd
Shaw-Petrie Ltd
Simmons & Hawker Ltd
Stewarts & Lloyds Ltd
Sykes Ltd, Henry
Talbot Stead Tube Co Ltd
TI Nuclear Engineering Ltd
Unit Superheater & Pipe Co Ltd
Wellington Tube Works Ltd
Wilmot Breeden Ltd

PIPE FLANGES
★ Circle *No 408* on reply card
Babcock & Wilcox Ltd
Blundell & Crompton Ltd
British Steam Specialties Ltd
Capper & Co Ltd, William H.
Freeman, Taylor Machines Ltd
General Steel Group
Kirk & Co (tubes) Ltd
Leybold Vacuum Sales Ltd
Marston Excelsior Ltd
Mendip (Chem. Eng.) Ltd. (non-metallic)
Oxley & Co Ltd, Wm. (stainless steel)
Press & Son Ltd, William
Rediweld Ltd
Robertson & Ferguson Ltd
Ryder & Co (Manchester) Ltd, Thomas
Simmons & Hawker Ltd
Stainless Steel Profile Cutters Ltd
Stewarts & Lloyds Ltd
Talbot Stead Tube Co Ltd
TI Nuclear Engineering Ltd
Unit Superheater & Pipe Co Ltd
Walker Ltd, C. & W.

PIPE SUPPORTS
★ Circle *No 409* on reply card
Aiton & Co Ltd
Babcock & Wilcox Ltd
Blundell & Crompton Ltd
British Industrial Engineering Co (Staffs) Ltd
British Steam Specialties Ltd
Capper & Co Ltd, William H.
Follsain-Wycliffe Foundries Ltd
Harvey & Co (London) Ltd, G. A.
Kirk & Co (tubes) Ltd
Motherwell Bridge & Engineering Co Ltd
Munro & Miller Ltd
Press & Son, Ltd, William
QVF Ltd
Robertson & Ferguson Ltd
Ryder & Co (Manchester) Ltd, Thos.
Shaw-Petrie Ltd
Simmons & Hawker Ltd
Simon-Carves Ltd
Stewarts & Lloyds Ltd
Talbot Stead Tube Co Ltd
TI Nuclear Engineering Ltd
Unit Superheater & Pipe Co Ltd
Vokes Gensprings Ltd
Walker Ltd, C. & W.

PIPING—FLEXIBLE
★ Circle *No 410* on reply card
Abboflex Ltd
Accles & Pollock Ltd
Avica Equipment Ltd
British Steam Specialties Ltd
BTR Industries Ltd
BX Plastics Ltd
Clay Cross (Iron & Foundries) Ltd
Compoflex Co Ltd
Dunlop Rubber Co Ltd
Hellerman Ltd
Laboratory Apparatus & Glass Blowing Co
Leybold Vacuum Sales Ltd
Nuclear Engineering Ltd
Power Flexible Tubing Co Ltd, The
Shaw Glasgow Ltd
Shaw & McInnes Ltd
Smiths Industrial Instruments Ltd
Sykes Ltd, Henry
Teddington Aircraft Controls Ltd
TI Nuclear Engineering Ltd
Vicsons Ltd

PIPING—NON-FERROUS
★ Circle *No 411* on reply card
Abboflex Ltd (bronze; brass)
Accles & Pollock Ltd
Blundell & Crompton Ltd
Booth & Co Ltd, James
British Aluminium Co Ltd, The
British Ermeto Corporation Ltd (copper)
Caledonian Metal Co Ltd (copper; brass)
Compoflex Co Ltd
Costain-John Brown Ltd
Ellay Tubes Ltd (Brass, Copper, Aluminium & Light Alloys)
Fleischmann (London) Ltd
Hawker Siddeley Nuclear Power Co Ltd
Imperial Chemical Industries Ltd
London Metal Warehouses Ltd
Marston Excelsior Ltd (aluminium)
Mills Packard Construction Co Ltd
Millspaugh Ltd
Munro & Miller Ltd (all types)
Northern Aluminium Co Ltd (aluminium)
Nuclear Engineering Ltd
Smith & Sons (Clerkenwell) Ltd, J. (brass, copper, aluminium & aluminium alloys)
Southern Forge Ltd (aluminium alloys)
Wiggin & Co Ltd, Henry

PIPING—NON-METALLIC
★ Circle *No 412* on reply card
Abboflex Ltd (plastic)
Avica Equipment Ltd (synthetic rubber)
British Ermeto Corporation Ltd (rubber)
BX Plastics Ltd (plastic)
Compoflex Co Ltd
Doulton Industrial Porcelains Ltd (ceramic)
DuPont Ltd, Richard E.
Extrudex Ltd
Grey & Marten Ltd (plastic)
Hatherware Ltd (stoneware)
Imperial Chemical Industries Ltd

PIPING—NON-METALLIC—*continued*
Kestner Evaporator & Engineering Co Ltd (plastic)
Laboratory Apparatus & Glass Blowing Co
London Metal Warehouses Ltd
Mendip (Chemical Engineering) Ltd (Reinforced Plastic)
National Plastics Ltd (plastic)
QVF Ltd (glass)
Rediweld Ltd (plastic)
Sykes Ltd, Henry (plastic)
Telegraph Construction & Maintenance Co Ltd, The (plastic)
Thermal Syndicate Ltd, The (vitreosil)
Thermo-Plastics Ltd (plastic)
TI Nuclear Engineering Ltd (plastic)
Vicsons Ltd

PIPING—STAINLESS STEEL
★ Circle *No 413* on reply card
Aiton & Co Ltd
Accles & Pollock Ltd
APV Co Ltd, The
Babcock & Wilcox Ltd
Blundell & Crompton Ltd
Capper & Co Ltd, William H.
Chesterfield Tube Co Ltd, The
Compoflex Co Ltd
Cravens Ltd
Foster Wheeler Ltd
Grey & Marten Ltd
Head Wrightson & Co Ltd (Nuclear Power Div)
Horseley Bridge & Thomas Piggott Ltd
Incandescent Heat Co Ltd
London Metal Warehouses Ltd
Kirk & Co (Tubes) Ltd
Metal Propellers Ltd
Mills Packard Construction Co Ltd
Millspaugh Ltd
Motherwell Bridge & Engineering Co Ltd, The
Munro & Miller Ltd
Nuclear Engineering Ltd
Power Auxiliaries Ltd
Shaw-Petrie Ltd
Simmons & Hawker Ltd
Stainless Steel Vessels (London) Ltd
Talbot Stead Tube Co Ltd
Taylor Stainless Metals Co Ltd
Thompson (Pipework) Ltd, John
TI Nuclear Engineering Ltd
Tube Investments Ltd
Tube Products Ltd (Weldless)
Unit Superheater & Pipe Co Ltd
Ward Ltd, Thos W.

PIPING—STEAM
★ Circle *No 414* on reply card
Aiton & Co Ltd
Accles & Pollock Ltd
Allen & Sons (Tipton) Ltd, W. G.
Babcock & Wilcox Ltd
Blundell & Crompton Ltd
British Ermeto Corporation Ltd
British Steam Specialities Ltd
Capper & Co Ltd, William H.
Chesterfield Tube Co Ltd, The
Compoflex Co Ltd
Grey & Marten Ltd
Head Wrightson & Co Ltd (Nuclear Power Div)
Horseley Bridge & Thomas Piggott Ltd
Kirk & Co (Tubes) Ltd
Munro & Miller Ltd
Pearson & Sons Ltd, T. B.
Press & Son Ltd, William
Power Auxiliaries Ltd
Shaw & McInnes Ltd
Shaw-Petrie Ltd
Simmons & Hawker Ltd
Simon-Carves Ltd
Steels Engineering Installations Ltd
Stewarts & Lloyds Ltd
Stokes Taylor & Shaw Ltd
Talbot Stead Tube Co Ltd
Thompson (Pipework) Ltd, John
TI Nuclear Engineering Ltd
Unit Superheater & Pipe Co Ltd

PIPING—WATER
★ Circle *No 415* on reply card
Aiton & Co Ltd
Accles & Pollock Ltd
Allen & Sons (Tipton) Ltd, W. G.
Babcock & Wilcox Ltd
Blundell & Crompton Ltd
British Ermeto Corporation Ltd
British Steam Specialities Ltd
Capper & Co Ltd, William H.
Chesterfield Tube Co Ltd, The
Clay Cross (Iron & Foundries) Ltd
Compoflex Co Ltd
Extrudex Ltd
Foster Wheeler Ltd
Head Wrightson & Co Ltd (Nuclear Power Div)
Horseley Bridge & Thomas Piggott Ltd
Imperial Chemical Industries Ltd
Kirk & Co (Tubes) Ltd
Munro & Miller Ltd
Pearson & Sons Ltd, T. B.
Press & Son Ltd, William
Shaw & McInnes Ltd
Shaw Glasgow Ltd
Shaw-Petrie Ltd
Simmons & Hawker Ltd
Simon-Carves Ltd
Staveley Iron & Chemical Co Ltd, The
Steels Engineering Installations Ltd
Stewarts & Lloyds Ltd
Stokes Taylor & Shaw Ltd
Sykes Ltd, Henry
Talbot Stead Tube Co Ltd
Thompson (Pipework) Ltd, John
Unit Superheater & Pipe Co Ltd
Vicsons Ltd
Walker Ltd, C. & W.
Ward Ltd, Thos W.

PLASTICS
★ Circle *No 416* on reply card
Ayling Nuclear Equipment Co
Bakelite Ltd

PLASTICS—*continued*
Barytes (Shielding Products) Ltd
Berk & Co Ltd, F. W.—Schori Division
Bristol Aircraft Ltd
BX Plastics Ltd
Chemidus Plastics Ltd (corrosion resistant)
Combined Optical Industries Ltd
Dale Ltd, John
DuPont, Richard E.
Expanded Plastics Ltd
Extrudex Ltd
Fairey Aviation Co Ltd, The
General Electric Co Ltd, The
Hellerman Ltd
Imperial Chemical Industries Ltd
Kestner Evaporator & Engineering Co Ltd
Laboratory Apparatus & Glass Blowing Co
Marine & Industrial Plastics Ltd
Measurement Ltd
Mendip (Chemical Engineering) Ltd
Monsanto Chemicals Ltd
National Plastics Ltd
Napier & Son Ltd, D.
Permali Ltd
Prodorite Ltd
Redweld Ltd
Roberts Ltd, J. W.
Scientific Furnishings Ltd
Shell Chemical Co Ltd
Siemens Edison Swan Ltd
Southborough (Weybridge) Ltd
Spembly Ltd
Telegraph Construction & Maintenance Co Ltd
Thermo-Plastics Ltd
Vicsons Ltd

PNEUMATIC CONTROL EQUIPMENT
★ Circle *No 417* on reply card
Alexander Controls Ltd
Appleby & Ireland Ltd
Baldwin Instrument Co Ltd
Electro-Hydraulics Ltd
Elliott Bros (London) Ltd
Evans & Son (Portsmouth) Ltd, J.
Globe Pneumatic Eng Co Ltd
Gordon & Co Ltd, James
Hall & Co Ltd, Matthew
Integra, Leeds & Northrup Ltd
Kent Ltd, George
Lang Pneumatic Ltd
Martonair Ltd
Negretti & Zambra Ltd
Sigma Instrument Co Ltd
Sunvic Controls Ltd
Taylor Controls Ltd
Teddington Industrial Equipment Ltd
Thermocontrol Installations Co Ltd

POWDER METALLURGY PLANT
★ Circle *No 418* on reply card
Apex Construction Ltd
Cravens Ltd (Briquetting Presses)
Edwards High Vacuum Ltd
Leybold Vacuum Sales Ltd
Morton Machine Co Ltd

POWER TRANSMISSION EQUIPMENT
★ Circle *No 419* on reply card
British Thomson-Houston Co Ltd, The
Electropower Gears Ltd
Fenner & Co Ltd, J. H.
Renold Chains Ltd
Skefko Ball Bearing Co Ltd, The
Whittaker Hall & Co (1929) Ltd

PRECIPITATORS—ELECTROSTATIC *(See Dust Collectors)*

PRECIPITATORS—FISSION PRODUCT
★ Circle *No 420* on reply card
Dowty Nucleonics Ltd
Plessey Nucleonics Ltd
Robey & Co Ltd

PRESSURE VESSELS *(See Vessels—Pressure)*

PROCESS CONTROL EQUIPMENT
★ Circle *No 421* on reply card
Accurate Recording Instrument Co Ltd
AEW Ltd
Allied Electronics Ltd
Appleby & Ireland Ltd
Alto Instruments (GB) Ltd
Bailey & Co Ltd, Sir W. H.
British Thomson-Houston Co Ltd, The
Burndept Ltd
Cambridge Instrument Co Ltd
Chamberlain & Hookham Ltd
Crosby Valve & Engineering Co Ltd
Electro-Hydraulics Ltd
Elcontrol Ltd
Elliott Bros (London) Ltd
Evans & Son (Portsmouth) Ltd, J.
Evershed & Vignoles Ltd
Fairey Aviation Co Ltd, The
Fielden Electronics Ltd
General Electric Co Ltd, The
Gordon & Co Ltd, James
Hall & Co Ltd, Matthew
Heat Transfer Ltd
Hilger & Watts Ltd
Honeywell-Brown Ltd
Humphreys & Glasgow Ltd
Hutchison Duthie & Son Ltd, R.
Integra, Leeds & Northrup Ltd
Ionic Instruments (London) Ltd
Jones & Stevens Ltd
Kent Ltd, George
Ketay Ltd
Lancashire Dynamo Electronics Products Ltd
Lock & Co Ltd, A. M.
McKellan Automation Ltd
Measurement Ltd
Measuring Instruments (Pullin) Ltd
Metropolitan-Vickers Electrical Co Ltd
Nagard Ltd
Negretti & Zambra Ltd
Panax Equipment Ltd
Plessey Nucleonics Ltd
Pye Ltd

PROCESS CONTROL EQUIPMENT—*continued*
Reavell & Co Ltd
Research & Control Instruments Ltd
Ruston & Hornsby Ltd
Salford Electrical Instruments Ltd
Scaley Engineering Co Ltd
Sigma Instrument Co Ltd
Spembly Ltd
Sunvic Controls Ltd
Taylor Controls Ltd
Teddington Industrial Equipment Ltd
Thermocontrol Installations Co Ltd
Trist & Co Ltd, Ronald
Weyers Bros Ltd
Winston Electronics Ltd
Wright & Co Ltd, Alexander

PROTECTIVE CLOTHING
★ Circle *No 422* on reply card
Acetylene Generator & Tool Co Ltd
Andrews, Cuthbert
Arc Mfg Co Ltd
Baddeley Engineering Co Ltd, D. S.
British Industrial Gases Ltd
British Oxygen Gases Ltd
English Electric Co Ltd
Fleming Ltd, J. & R.
Lincoln Electric Co Ltd (Welders)
Metropolitan-Vickers Electrical Co Ltd
Milne & Co Ltd, C. S. (leather, asbestos, pvc)
Murex Welding Processes Ltd
Philips Electrical Ltd
Quasi-Arc Ltd (Welders)
Safety Products Ltd
Siebe, Gorman & Co Ltd
Spembly Ltd (pvc suits)
Suffolk Iron Foundry (1920) Ltd
Timeg Ltd
Turner Bros Asbestos Co Ltd
Welding Supplies Ltd
Young & Co Ltd, A. S.

PUMPS (BY TYPE)—AXIAL FLOW
★ Circle *No 423* on reply card
Allen Sons & Co Ltd, W. H.
Armstrong Siddeley Motors Ltd
Budworth Ltd, David
Gwynnes Pumps Ltd
Hamworthy Engineering Ltd
Harland Engineering Co Ltd
Pulsometer Engineering Co Ltd, The
Sigmund Pumps Ltd
Tangyes Ltd
Telehoist Ltd
Vickers-Armstrongs (Engineers) Ltd
Worthington-Simpson Ltd

PUMPS (BY TYPE)—CANNED MOTOR, GLANDLESS
★ Circle *No 424* on reply card
Harland Engineering Co Ltd
Hayward Tyler & Co Ltd
Palatine Tool & Engineering Co (Surbiton) Ltd
Sealed Motor Construction Co
Sigmund Pumps Ltd
Sumo Pumps Ltd
Weir Ltd, G. & J.

PUMPS (BY TYPE)—DIAPHRAGM
★ Circle *No 425* on reply card
Brackett & Co Ltd, F. W.
CT (London) Ltd
Distillers Co Ltd, The
Doulton Industrial Porcelains Ltd
ECD Ltd
Girdlestone Pumps Ltd
Johnson & Co Ltd, S. H.
Mitchell Ltd, L. A.
Pulsometer Engineering Co Ltd, The
Simm Engineering Ltd, G. E.
SPE Co Ltd
Sykes Ltd, Henry
Ward Ltd, Thos W.
Wilkinson Rubber Linatex Ltd

PUMPS (BY TYPE)—ELECTROMAGNETIC, a.c. CONDUCTION
★ Circle *No 426* on reply card
British Thomson-Houston Co Ltd, The
Palatine Tool & Engineering Co Ltd, The

PUMPS (BY TYPE—ELECTROMAGNETIC, d.c. CONDUCTION
★ Circle *No 427* on reply card
British Thomson-Houston Co Ltd, The

PUMPS (BY TYPE)—ELECTROMAGNETIC, a.c. INDUCTION, FLAT LINEAR
★ Circle *No 428* on reply card
British Thomson-Houston Co Ltd, The
English Electric Co Ltd, The
Palatine Tool & Engineering Co (Surbiton) Ltd

PUMPS (BY TYPE—ELECTROMAGNETIC, a.c. INDUCTION, ANNULAR LINEAR
★ Circle *No 429* on reply card
British Thomson-Houston Co Ltd, The

PUMPS (BY TYPE) ELECTROMAGNETIC, a.c. INDUCTION, SPIRAL
★ Circle *No 430* on reply card
British Thomson-Houston Co Ltd, The

PUMPS (BY TYPE)—ELECTROMAGNETIC, a.c. INDUCTION, ROTATING MAGNET
★ Circle *No 431* on reply card
English Electric Co Ltd, The

PUMPS (BY TYPE)—GAS BEARING
★ Circle *No 432* on reply card
Armstrong Siddeley Motors Ltd
Bell Precision Engineering Co Ltd
Palatine Tool & Engineering Co (Surbiton) Ltd
Ruston & Hornsby Ltd

PUMPS (BY TYPE)—GEAR OR LOBE ROTARY
★ Circle *No 433* on reply card
Angus & Co Ltd, George
Autometric Pumps Ltd
BSA Tools Ltd

PUMPS (BY TYPE)—GEAR OR LOBE ROTARY—*continued*
Freeman, Taylor Machines Ltd
Godwin Ltd, H. J.
Hamworthy Engineering Ltd
Hydraulics & Pneumatics Ltd
Integral Ltd
Measurement Ltd
Northey Rotary Compressors Ltd
Parkinson & Cowan Ltd
Plenty & Son Ltd
Varley-FMC Ltd
Wade Engineering Ltd
Weyers Bros Ltd

PUMPS (BY TYPE)—HORIZONTAL, CENTRIFUGAL
★ Circle *No 434* on reply card
Appleton & Howard Ltd
APV Co Ltd, The
Autometric Pumps Ltd
Bell Precision Engineering Co Ltd
Berry Hill (Engineers) Ltd
British LaBour Pump Co Ltd
Budworth Ltd, David
Cellulose Development Corporation Ltd
Clarke, Chapman & Co Ltd
Doulton Industrial Porcelains Ltd
Filton Ltd
Godwin Ltd, H. J.
Gwynnes Pumps Ltd
Hamworthy Engineering Ltd
Harland Engineering Co Ltd
Hathernware Ltd
Hayward Tyler & Co Ltd
Hick Hargreaves & Co Ltd
Hughes & Lancaster Ltd
Kestner Evaporator & Engineering Co Ltd
Lee, Howl & Co Ltd
Lyon & Co Ltd, Arthur
Mackley & Co Ltd, E. N.
Pulsometer Engineering Co Ltd, The
Ruston & Hornsby Ltd
Saunders Valve Co Ltd
Sigmund Pumps Ltd
Simm Engineering Ltd, G. E.
Sykes Ltd, Henry
Tangyes Ltd
Ward Ltd, Thos W.
Wayne Tank & Pump Co Ltd
Weir Ltd, G. & J.
Wilkinson Rubber Linatex Ltd
Worthington-Simpson Ltd

PUMPS (BY TYPE)—MAGNETIC COUPLING, GLANDLESS
★ Circle *No 435* on reply card
Hydraulic & Mechanical Developments Ltd
Palatine Tool & Engineering Co (Surbiton) Ltd

PUMPS (BY TYPE)—METERING
★ Circle *No 436* on reply card
Candy Filter Co Ltd, The
Distillers Co Ltd, The
ECD Ltd
Kingsbourne Products Ltd
Matterson Ltd
Ormerod Engineering Ltd
Parkinson & Cowan Ltd
Plenty & Son Ltd
Savery (Pumps), Ltd, Thomas
TI Nuclear Engineering Ltd
Telehoist Ltd

PUMPS (BY TYPE)—MIXED FLOW
★ Circle *No 437* on reply card
Allen Sons & Co Ltd, W. H.
Gwynnes Pumps Ltd
Harland Engineering Co Ltd
Hayward Tyler & Co Ltd
Pulsometer Engineering Co Ltd, The
Sigmund Pumps Ltd
Sumo Pumps Ltd
Tangyes Ltd
Vickers-Armstrongs (Engineers) Ltd
Worthington-Simpson Ltd

PUMPS (BY TYPE)—MULTI-CYLINDER, RECIPROCATING
★ Circle *No 438* on reply card
Bailey & Co Ltd, Sir W. H.
Brackett & Co Ltd, F. W.
Candy Filter Co Ltd, The
Clarke, Chapman & Co Ltd
Carruthers & Co Ltd, J. H.
ECD Ltd
Godwin Ltd, H. J.
Hayward Tyler & Co Ltd
Hydraulics & Pneumatics Ltd
Johnson & Co Ltd, S. H.
Lee, Howl & Co Ltd
Leeds Engineering & Hydraulic Co Ltd, The
Lloyd & Ross Ltd
Mackley & Co, E. N.
Matterson Ltd
Plenty & Son Ltd
Pulsometer Engineering Co Ltd, The
Spenborough Engineering Co Ltd
Sykes Ltd, Henry
Tangyes Ltd
Telehoist Ltd
Towler Bros (Patents) Ltd
Tubela Engineering Co Ltd
Weir Ltd, G. & J.
Williams & James (Engineers) Ltd
Wilson & Son Ltd, Edward
Worthington-Simpson Ltd

PUMPS (BY TYPE)—MULTISTAGE CENTRIFUGAL
★ Circle *No 439* on reply card
Berry Hill (Engineers) Ltd
Budworth Ltd, David
Clarke, Chapman & Co Ltd
Gwynnes Pumps Ltd
Hamworthy Engineering Ltd

PUMPS (BY TYPE)—MULTISTAGE, CENTRIFUGAL—*continued*
Harland Engineering Co Ltd
Hayward Tyler & Co Ltd
Hick, Hargreaves & Co Ltd
Holden & Brooke Ltd
Lee, Howl & Co Ltd
Mackley & Co, E. N.
Pulsometer Engineering Co Ltd
Saunders Valve Co Ltd
Sigmund Pumps Ltd
Sumo Pumps Ltd
Sykes Ltd, Henry
Tangyes Ltd
Weir Ltd, G. & J.
Worthington-Simpson Ltd

PUMPS (BY TYPE)—SCREW OR HELIX, ROTARY
★ Circle *No 440* on reply card
Hamworthy Engineering Ltd
Mason (Chemical Engineers) Ltd, G. Samuel
Mirrlees (Engineers) Ltd
Mono Pumps Ltd
Pulsometer Engineering Co Ltd, The
Telehoist Ltd
Varley-FMC Ltd

PUMPS (BY TYPE)—SELF-PRIMING, CENTRIFUGAL
★ Circle *No 441* on reply card
Autometric Pumps Ltd
British LaBour Pump Co Ltd
Budworth Ltd, David
Carruthers & Co Ltd, J. H.
Coventry Climax Engines Ltd
Godwin Ltd, H. J.
Hamworthy Engineering Ltd
Harland Engineering Co Ltd
Hayward Tyler & Co Ltd
Kestner Evaporator & Engineering Co Ltd
Lee, Howl & Co Ltd
Pulsometer Engineering Co Ltd, The
Ransomes & Rapier Ltd
Saunders Valve Co Ltd
Sigmund Pumps Ltd
SPE Co Ltd
Sykes Ltd, Henry
Ward Ltd, Thos W.
Worthington-Simpson Ltd

PUMPS (BY TYPE)—SINGLE CYLINDER, RECIPROCATING
★ Circle *No 442* on reply card
Brackett & Co Ltd, F. W.
Candy Filter Co Ltd, The
Clarke, Chapman & Co Ltd
ECD Ltd
Godwin Ltd, H. J.
Grease Appliance Co Ltd
Johnson & Co Ltd, S. H.
Kingsbourne Products Ltd
Lee, Howl & Co Ltd
Mackley & Co, E. N.
Matterson Ltd
Merrill Pumps Ltd
Parkinson & Cowan Ltd
Pulsometer Engineering Co Ltd
Sykes Ltd
Tangyes Ltd
Weir Ltd, G. & J.
Williams & James (Engineers) Ltd
Worthington-Simpson Ltd

PUMPS (BY TYPE)—SUBMERGED MOTOR, GLANDLESS
★ Circle *No 443* on reply card
Appleton & Howard Ltd
Bell Precision Engineering Co Ltd
Hamworthy Engineering Ltd
Harland Engineering Co Ltd
Hayward Tyler & Co Ltd
Palatine Tool & Engineering Co Ltd
Pulsometer Engineering Co Ltd
Sealed Motor Construction Co Ltd
Sumo Pumps Ltd
Worthington-Simpson Ltd

PUMPS (BY TYPE)—VANE ROTARY
★ Circle *No 444* on reply card
Kestner Evaporator & Engineering Co Ltd
Liquid Systems Ltd
Plenty & Son Ltd
Spenborough Engineering Co Ltd
Stein Atkinson Vickers Hydraulics Ltd
Weyers Bros Ltd
Whittaker Hall & Co (1929) Ltd
Williams & James (Engineers) Ltd

PUMPS (BY TYPE)—VARIABLE DELIVERY, RECIPROCATING
★ Circle *No 445* on reply card
Ashwell & Nesbit Ltd
Candy Filter Co Ltd, The
Distillers Co Ltd, The
Hydraulics & Pneumatics Ltd
Integral Ltd
Kingsbourne Products Ltd
Lee, Howl & Co Ltd
Matterson Ltd
Measurement Ltd
Ormerod Engineers Ltd
Parkinson & Cowan Ltd
Plenty & Son Ltd
Pulsometer Engineering Co Ltd, The
Savery Pumps Ltd, Thomas
Tangyes Ltd
Telehoist Ltd
Towler Bros (Patents) Ltd
Tubela Engineering Co Ltd
Vickers-Armstrongs (Engineers) Ltd
Williams & James (Engineers) Ltd

PUMPS (BY TYPE)—VERTICAL, CENTRIFUGAL
★ Circle *No 446* on reply card
Appleton & Howard Ltd
APV Co Ltd, The
Armstrong Siddeley Motors Ltd
Berry Hill (Engineers) Ltd
British LaBour Pump Co Ltd (Glandless)

PUMPS (BY TYPE)—VERTICAL, CENTRIFUGAL—*continued*
Budworth Ltd, David
Carrutaers & Co Ltd, J. H.
Filton Ltd
Gwynnes Pumps Ltd
Hamworthy Engineering Ltd
Hayward Tyler & Co Ltd
Holden & Brooke Ltd
Hughes & Lancaster Ltd
Kestner Evaporator & Engineering Co Ltd
Pulsometer Engineering Co Ltd, The
Rhodes, Brydon & Youatt Ltd
Saunders Valve Co Ltd
Sykes Ltd, Henry
Tangyes Ltd
Tubela Engineering Co Ltd
Ward Ltd, Thos. W.
Weir Ltd, G. & J.
Wilkinson Rubber Linatex Ltd
Williams & James (Engineers) Ltd
Worthington-Simpson Ltd

PUMPS (BY TYPE)—WATER-RING, CENTRIFUGAL
★ Circle *No 447* on reply card
Autometric Pumps Ltd
Coventry Climax Engines Ltd
Hamworthy Engineering Ltd
Lee, Howl & Co Ltd
Pulsometer Engineering Co Ltd, The
Rhodes, Brydon & Youatt Ltd
Sigmund Pumps Ltd
Worthington-Simpson Ltd

PUMPS—VACUUM *(See Section 2)*

PUMPS (BY PURPOSE)—ACIDS
★ Circle *No 448* on reply card
Appleton & Howard Ltd
Autometric Pumps Ltd
British LaBour Pump Co Ltd
Candy Filter Co Ltd, The
Clarke, Chapman & Co Ltd
CT (London) Ltd
Distillers Co Ltd, The
Doulton Industrial Porcelains Ltd
ECD Ltd
Extrudex Ltd
Freeman, Taylor Machines Ltd
Gwynnes Pumps Ltd
Harland Engineering Co Ltd
Harris (Birmingham) Ltd, F. & R. M.
Hathernware Ltd
Hayward Tyler & Co Ltd
Holden & Brooke Ltd
Johnson & Co Ltd, S. H.
Kestner Evaporator & Engineering Co Ltd
Leeds Engineering & Hydraulic Co Ltd
Merrill Pumps Ltd
Mono Pumps Ltd
Ormerod Engineers Ltd
Palatine Tool & Engineering Co (Surbiton) Ltd
Parkinson & Cowan Ltd
Plenty & Son Ltd
Pulsometer Engineering Co Ltd, The
Saunders Valve Co Ltd
Sigmund Pumps Ltd
Sykes Ltd, Henry
Tangyes Ltd
TI Nuclear Engineering Ltd
Wilkinson Rubber Linatex Ltd
Worthington-Simpson Ltd

PUMPS (BY PURPOSE)—BOILER CIRCULATOR
★ Circle *No 449* on reply card
Allen Sons & Co Ltd, W. H.
Appleton & Howard Ltd
British LaBour Pumps Ltd
Carruthers & Co Ltd, J. H.
Clarke, Chapman & Co Ltd
CT (London) Ltd
Gilkes & Gordon Ltd, Gilbert
Girdlestone Pumps Ltd
Gwynnes Pumps Ltd
Hamworthy Engineering Ltd
Harland Engineering Co Ltd
Hayward Tyler & Co Ltd
Kestner Evaporator & Engineering Co Ltd
Lee, Howl & Co Ltd
Pulsometer Engineering Co Ltd, The
Ransomes & Rapier Ltd
Saunders Valve Co Ltd
Sigmund Pumps Ltd
Simon-Carves Ltd
Sykes Ltd, Henry
Tangyes Ltd
Weir Ltd, G. & J.
Worthington-Simpson Ltd
Wrights Electric Motors (Halifax) Ltd

PUMPS (BY PURPOSE)—BOILER FEED
★ Circle *No 450* on reply card
Autometric Pumps Ltd
Berry Hill (Engineers) Ltd
Clarke, Chapman & Co Ltd
Gilkes & Gordon Ltd, Gilbert
Godwin Ltd, H. J.
Hamworthy Engineering Ltd
Harland Engineering Co Ltd
Hayward Tyler & Co Ltd
Lee, Howl & Co Ltd
Leeds Engineering & Hydraulic Co Ltd, The
Mono Pumps Ltd
Parkinson & Cowan Ltd
Plenty & Son Ltd
Pulsometer Engineering Co Ltd, The
Saunders Valve Co Ltd
Sigmund Pumps Ltd
Simon-Carves Ltd
Tangyes Ltd
Weir Ltd, G. & J.
Williams & James (Engineers) Ltd
Worthington-Simpson Ltd
Wright Electric Motors (Halifax) Ltd

PUMPS (BY PURPOSE)—COLD WATER
★ Circle *No 451* on reply card
Allen Sons & Co Ltd, W. H.
Armstrong Whitworth (Met. Ind.) Ltd
Autometric Pumps Ltd

PUMPS (BY PURPOSE)—COLD WATER—*continued*
Bailey & Co Ltd, Sir W. H.
Berry Hill (Engineers) Ltd
Brackett & Co Ltd, F. W.
British LaBour Pump Co Ltd
British Steam Specialties Ltd
BSA Tools Ltd
Budworth Ltd, David
Clarke, Chapman & Co Ltd
Coventry Climax Engines Ltd
CT (London) Ltd
Freeman, Taylor Machines Ltd
Gilkes & Gordon Ltd, Gilbert
Globe Pneumatic Eng Co Ltd
Godwin Ltd, H. J.
Gwynnes Pumps Ltd
Hamworthy Engineering Ltd
Harland Engineering Co Ltd
Hayward Tyler & Co Ltd
Holden & Brooke Ltd
Lee, Howl & Co Ltd
Leeds Engineering & Hydraulic Co Ltd, The
Liquid Systems Ltd
Lyon & Co Ltd, Arthur
Mackley & Co, E. N.
Madan & Co Ltd, Charles S.
Mono Pumps Ltd
Ormerod Engineers Ltd
Parkinson & Cowan Ltd
Plenty & Son Ltd
Pulsometer Engineering Co Ltd, The
Ransomes & Rapier Ltd
Ruston & Hornsby Ltd
Saunders Valve Co Ltd
Sealed Motor Construction Co Ltd
Sigmund Pumps Ltd
Sumo Pumps Ltd
Sykes Ltd, Henry
Tangyes Ltd
Varley-FMC Ltd
Vickers-Armstrongs (Engineers) Ltd
Weir Ltd, G. & J.
Williams & James (Engineers) Ltd
Wilson & Son Ltd, Edward
Worthington-Simpson Ltd
Wrights Electric Motors (Halifax) Ltd

PUMPS (BY PURPOSE)—CONDENSATE EXTRACTION
★ Circle *No 452* on reply card
Appleton & Howard Ltd
Autometric Pumps Ltd
British LaBour Pump Co Ltd
Budworth Ltd, David
Clarke, Chapman & Co Ltd
CT (London) Ltd
Girdlestone Pumps Ltd
Hamworthy Engineering Ltd
Kingsbourne Products Ltd
Lee, Howl & Co Ltd
Liquid Systems Ltd
Pulsometer Engineering Co Ltd, The
Ransomes & Rapier Ltd
Rhodes, Brydon & Youatt Ltd
Saunders Valve Co Ltd
Sigmund Pumps Ltd
Tangyes Ltd
Weir Ltd, G. & J.
Worthington-Simpson Ltd
Wrights Electric Motors (Halifax) Ltd

PUMPS (BY PURPOSE)—HEAVY WATER
★ Circle *No 453* on reply card
Appleton & Howard Ltd
British LaBour Pump Co Ltd
Coventry Climax Engines Ltd
CT (London) Ltd
ECD Ltd
Harland Engineering Co Ltd
Hayward Tyler & Co Ltd
Hydraulic & Mechanical Developments Ltd
Lee, Howl & Co Ltd
Merrill Pumps Ltd
Plenty & Son Ltd
Sigmund Pumps Ltd
Weir Ltd, G. & J.

PUMPS (BY PURPOSE)—LIQUID METALS (ELECTROMAGNETIC)
★ Circle *No 454* on reply card
British Thomson-Houston Co Ltd, The
English Electric Co Ltd, The
Palatine Tool & Engineering Co (Surbiton) Ltd

PUMPS (BY PURPOSE)—LIQUID METALS (MECHANICAL)
★ Circle *No 455* on reply card
Appleton & Howard Ltd
Armstrong Siddeley Motors Ltd
Bell Precision Engineering Co Ltd
British Thomson-Houston Co Ltd, The
ECD Ltd
Hayward Tyler & Co Ltd
Palatine Tool & Engineering Co (Surbiton) Ltd

PUMPS (BY PURPOSE)—OILS
★ Circle *No 456* on reply card
Appleton & Howard Ltd
Armstrong Siddeley Motors Ltd
Armstrong Whitworth (Met. Ind.) Ltd
Autometric Pumps Ltd
British LaBour Pump Co Ltd
BSA Tools Ltd
Candy Filter Co Ltd, The
Carruthers & Co Ltd, J. H.
Clarke, Chapman & Co Ltd
Coventry Climax Engines Ltd
CT (London) Ltd
ECD Ltd
Fielding & Platt Ltd
Freeman, Taylor Machines Ltd
Grease Appliance Co Ltd
Gwynnes Pumps Ltd
Hamworthy Engineering Ltd
Harland Engineering Co Ltd
Hayward Tyler & Co Ltd
Holden & Brooke Ltd
Hydraulics & Pneumatics Ltd
Integral Ltd
Keelavite Hydraulics Ltd
Lee, Howl & Co Ltd

PUMPS (BY PURPOSE)—OILS—*continued*
Liquid Systems Ltd
Madan & Co Ltd, Charles S.
Measurement Ltd
Mirrlees Ltd
Mono Pumps Ltd
Ormerod Engineers Ltd
Parkinson & Cowan Ltd
Plenty & Son Ltd
Pulsometer Engineering Co Ltd, The
Rhodes, Brydon & Youatt Ltd
Savery Pumps Ltd, Thomas
Saunders Valve Co Ltd
Sigmund Pumps Ltd
Stein Atkinson Vickers Hydraulics Ltd
Tangyes Ltd
Telehoist Ltd
Tecalemit Ltd
Varley-FMC Ltd
Wakefield-Dick Industrial Oils Ltd
Wayne Tank & Pump Co Ltd
Weir Ltd, G. & J.
Worthington-Simpson Ltd

PUMPS (BY PURPOSE)—ORGANIC FLUIDS
★ Circle *No 457* on reply card
Appleton & Howard Ltd
Armstrong Siddeley Motors Ltd
British LaBour Pump Co Ltd
Clarke, Chapman & Co Ltd
Distillers Co Ltd, The
ECD Ltd
Freeman, Taylor Machines Ltd
Gwynnes Pumps Ltd
Harland Engineering Co Ltd
Hayward Tyler & Co Ltd
Lee, Howl & Co Ltd
Measurement Ltd
Mono Pumps Ltd
Parkinson & Cowan Ltd
Pulsometer Engineering Co Ltd, The
Saunders Valve Co Ltd
Sigmund Pumps Ltd
Sykes Ltd, Henry
Tangyes Ltd

PUMPS (BY PURPOSE)—SEA WATER
★ Circle *No 458* on reply card
Allen Sons & Co Ltd, W. H.
Appleton & Howard Ltd
Armstrong Whitworth (Met. Ind.) Ltd
Autometric Pumps Ltd
Berry Hill (Engineers) Ltd
British LaBour Pump Co Ltd
Budworth Ltd, David
Cellulose Development Corporation Ltd
Clarke, Chapman & Co Ltd
Coventry Climax Engines Ltd
CT (London) Ltd
Gilkes & Gordon Ltd, Gilbert
Girdlestone Pumps Ltd
Godwin Ltd, H. J.
Gwynnes Pumps Ltd
Hamworthy Engineering Co Ltd
Harland Engineering Co Ltd
Hayward Tyler & Co Ltd
Holden & Brooke Ltd
Kestner Evaporator & Engineering Co Ltd
Kingsbourne Products Ltd
Lee, Howl & Co Ltd
Leeds Engineering & Hydraulic Co Ltd, The
Liquid Systems Ltd
Mackley & Co, E. N.
Mono Pumps Ltd
Ormerod Engineers Ltd
Pulsometer Engineering Co Ltd, The
Ruston & Hornsby Ltd
Ransomes & Rapier Ltd
Rhodes, Brydon & Youatt Ltd
Saunders Valve Co Ltd
Sigmund Pumps Ltd
Sumo Pumps Ltd
Sykes Ltd, Henry
Tangyes Ltd
Vickers-Armstrongs (Engineers) Ltd
Weir Ltd, G. & J.
Worthington-Simpson Ltd

PUMPS (BY PURPOSE)—SEMI-SOLIDS
★ Circle *No 459* on reply card
Appleton & Howard Ltd
Armstrong Whitworth (Met. Ind.) Ltd
Brackett & Co Ltd, F. W.
British Steam Specialities Ltd
Centralube Ltd
Clarke, Chapman & Co Ltd
ECD Ltd
Globe Pneumatic Eng Co Ltd
Godwin Ltd, H. J.
Gwynnes Pumps Ltd
Harland Engineering Co Ltd
Holden & Brooke Ltd
Hughes & Lancaster Ltd
Johnson & Co Ltd, S. H.
Lee, Howl & Co Ltd
Leeds Engineering & Hydraulic Co Ltd, The
Mackley & Co, E. N.
Madan & Co Ltd, Charles S.
Mono Pumps Ltd
Pulsometer Engineering Co Ltd, The
Ransomes & Rapier Ltd
Sigmund Pumps Ltd
Sykes Ltd, Henry
Tangyes Ltd
Wilson & Son Ltd, Edward
Worthington-Simpson Ltd

PUMPS (BY PURPOSE)—SLURRY
★ Circle *No 460* on reply card
Allen & Co Ltd, Edgar
Appleton & Howard Ltd
Armstrong Siddeley Motors Ltd
Bell Precision Engineering Co Ltd
Brackett & Co Ltd, F. W.
British LaBour Pump Co Ltd
BSA Tools Ltd
Candy Filter Co Ltd, The
Cellulose Development Corporation Ltd
Clarke, Chapman & Co Ltd

PUMPS (BY PURPOSE)—SLURRY—*continued*
Consolidated Pneumatic Tool Co Ltd, The
ECD Ltd
General Electric Co Ltd, The
Gwynnes Pumps Ltd
Harland Engineering Co Ltd
Hayward Tyler & Co Ltd
Holden & Brooke Ltd
Hughes & Lancaster Ltd
Johnson & Co Ltd, S. H.
Kestner Evaporator & Engineering Co Ltd
Kingsbourne Products Ltd
Lee, Howl & Co Ltd
Leeds Engineering & Hydraulic Co Ltd, The
Mackley & Co Ltd, E. N.
Measurement Ltd
Merrill Pumps Ltd
Mono Pumps Ltd
Parkinson & Cowan Ltd
Pulsometer Engineering Co Ltd, The
Ransomes & Rapier Ltd
Saunders Valve Co Ltd
Sigmund Pumps Ltd
Spembly Ltd
Sumo Pumps Ltd
Sykes Ltd, Henry
Tangyes Ltd
Varley-FMC Ltd
Watson-Marlow Air pump Co, The
Wilkinson Rubber Linatex Ltd
Wilson & Son Ltd, Edward
Worthington-Simpson Ltd

PURGE UNITS
★ Circle *No 461* on reply card
Marston Excelsior Ltd
Pulsometer Engineering Co Ltd, The

PURIFIERS—OIL
★ Circle *No 462* on reply card
Sharples Centrifuges Ltd
Stream-Line Filters Ltd

RADIOGRAPHIC EQUIPMENT—INDUSTRIAL
★ Circle *No 463* on reply card
Andrews, Cuthbert
Arc Mfg Co Ltd
Butterfield Ltd, W. P.
Falk & Co Ltd, M.
Gamma-Rays Ltd
Ilford Ltd
Industrial Radiography (NDT) Ltd
Marconi Instruments Ltd
Marine & Industrial Plastics Ltd
Metropolitan-Vickers Electrical Co Ltd
Mullard Ltd
Newton Victor Ltd
Nuclear Engineering Ltd
Palmer Aero Products Ltd
Pantak Ltd
Philips Electrical Ltd
Welding Supervision Ltd
Welding Supplies Ltd

RADIOGRAPHIC SERVICES—INDUSTRIAL
★ Circle *No 464* on reply card
Arc Mfg Co Ltd
Ashmore, Benson, Pease & Co
BTR Industries Ltd
Falk & Co Ltd, M.
Gamma-Rays Ltd
Glass Developments Ltd
Metropolitan-Vickers Electrical Co Ltd
Motherwell Bridge & Engineering Co Ltd, The
Munro & Miller Ltd
Newton, Chambers & Co Ltd
Pantak Ltd
Unit Superheater & Pipe Co Ltd
Welding Supervision Ltd
Western Detail Mfrs Ltd

REACTORS, NUCLEAR—BOILING WATER
★ Circle *No 465* on reply card
Adamson & Co Ltd, Daniel
Mitchell Engineering Ltd
Motherwell Bridge & Engineering Co Ltd, The
Nuclear Power Plant Co Ltd, The

REACTORS, NUCLEAR—GAS-COOLED
★ Circle *No 466* on reply card
AEI-John Thompson Nuclear Energy Co Ltd
Atomic Power Constructions Ltd
Babcock & Wilcox Ltd
English Electric Co Ltd, The
General Electric Co Ltd, The
Hawker Siddeley Nuclear Power Co Ltd
Head Wrightson & Co Ltd (Nuclear Power Div)
Nuclear Power Plant Co Ltd, The

REACTORS, NUCLEAR—PRESSURIZED WATER
★ Circle *No 467* on reply card
Babcock & Wilcox Ltd
Humphreys & Glasgow Ltd

REACTORS, NUCLEAR—RESEARCH
(See Section 2)

RECTIFIERS—MERCURY ARC
★ Circle *No 468* on reply card
ASEA Electric Ltd
British Thomson-Houston Co Ltd, The
Electric Construction Co Ltd, The
English Electric Co Ltd, The
General Electric Co Ltd, The
Hackbridge & Hewittic Electric Co Ltd
Lancashire Dynamo Nevelin Ltd
Metropolitan-Vickers Electrical Co Ltd
Research & Control Instruments Ltd

REFLUX DIVIDERS
★ Circle *No 469* on reply card
Metal Propellers Ltd
QVF Ltd

REFRACTORIES
★ Circle *No 470* on reply card
Carborundum Co Ltd, The
Castle Fire Brick Co Ltd, The
Curtis & Co, A. L.
English Clays, Lovering Pochin & Co Ltd

REFRACTORIES—*continued*
General Refractories Ltd
Lafarge Aluminous Cement Co Ltd
Morgan Refractories Ltd
New Metals & Chemicals Ltd
Podmore & Sons Ltd, W.
Prodorite Ltd
Simon-Carves Ltd
Thermal Syndicate Ltd, The

REFRIGERATION PLANT
★ Circle *No 471* on reply card
Brotherhood Ltd, Peter
Heat Transfer Ltd
Lightfoot Refrigeration Co Ltd, The
Perfection Parts Ltd
Western Detail Mfrs Ltd

REGULATORS—FEED WATER
★ Circle *No 472* on reply card
Gordon & Co Ltd, James
Taylor Controls Ltd
Trist & Co Ltd, Ronald
Weir Ltd, G. & J.

ROCK DRILLS
★ Circle *No 473* on reply card
Atlas Copco Ltd
Broom & Wade Ltd
Consolidated Pneumatic Tool Co Ltd, The
Electro-Hydraulics Ltd
Holman Bros Ltd

RUBBER GOODS—MECHANICAL
★ Circle *No 474* on reply card
Angus & Co Ltd, George
BTR Industries Ltd
Dunlop Rubber Co Ltd
Expanded Rubber Co Ltd
Fenner & Co Ltd, J. H.
Laboratory Apparatus & Glass Blowing Co
Metalastik Ltd
Precision Rubbers Ltd
Trist & Co Ltd, Ronald
Walker & Co Ltd, James
Wilkinson Rubber Linatex Ltd

SAND & SHOT BLASTING EQUIPMENT
★ Circle *No 475* on reply card
Airnesco Products Ltd (Sand Blasting)
Berk & Co Ltd, F. W.—Schori Division (both types)
BTR Industries Ltd (both types)
Curtis & Co, A. L. (both types)
Eutectic Welding Alloys Ltd
Guyson Industrial Equipment Ltd (both types)
Jackman & Co Ltd, J. W.
Metallising Equipment Co Ltd
Vacu-Blast Ltd

SCAFFOLDING—STEEL
★ Circle *No 476* on reply card
Booth & Co Ltd, James
Kwikform Ltd
Mills Scaffold Co Ltd
Stewarts & Lloyds Ltd
Sterling Foundry Specialities Ltd

SCREENS—MINERAL DRESSING
★ Circle *No 477* on reply card
Allen & Co Ltd, Edgar
Endecotts (Filters) Ltd
General Electric Co Ltd, The
Hadfields Ltd
Harvey & Co (London) Ltd, G. A.
Podmore & Sons Ltd, W.

SEALS—MECHANICAL SHAFT
★ Circle *No 478* on reply card
Angus & Co Ltd, George
Armstrong Whitworth (Met. Ind.) Ltd
Avica Equipment Ltd
Baker & Sons (Sales) Ltd, P. W.
Babcock & Wilcox Ltd
Callow (Engineers) Ltd, F. E
Crane Packing Ltd
Filton Ltd
Flexibox Ltd
General Electric Co Ltd, The
Morgan Crucible Co Ltd, The
Palatine Tool & Engineering Co (Surbiton) Ltd
Pioneer Oilsealing & Moulding Co Ltd
Powell Duffryn Carbon Products Ltd
Precision Rubbers Ltd (silicone rubber)
Trist & Co Ltd, Ronald
Tube Investments Ltd
United States Metallic Packing Co Ltd

SEPARATORS—STEAM
★ Circle *No 479* on reply card
Aiton & Co Ltd
Babcock & Wilcox Ltd
Blundell & Crompton Ltd
British Steam Specialities Ltd
Cockburns Ltd
Foster Wheeler Ltd
Gordon & Co Ltd, James
Simon-Carves Ltd
Stewarts & Lloyds Ltd
Stokes Taylor & Shaw Ltd
Superheater Co Ltd, The
United States Metallic Packing Co Ltd

SHIELDING—BIOLOGICAL
★ Circle *No 480* on reply card
Andrews, Cuthbert (Lead Lined)
Barytes (Shielding Products) Ltd
British Lead Mills Ltd (lead)
Cairns & Co Ltd, John J. (barytes aggregates)
Chatwood-Milner Ltd (Lead)
Cornwall Mills Ltd (Barytes)
General Electric Co Ltd (heavy alloy)
General Metal Utilisation (lead)
General Radiological Ltd (Fabricated)
Grazebrook Ltd, M. & W.
Haywards Steel Doors Ltd (doors)
International Meehanite Metal Co Ltd, The
Isotope Developments Ltd
Mills Packard Construction Co Ltd (Lead)
Mitchell Engineering Ltd (Concrete)
Newton Victor Ltd (Lead)

SHIELDING—BIOLOGICAL—*continued*
Nuclear Engineering Ltd
Optical Works Ltd
Permali Ltd
Pilkington Bros Ltd
Price, Charles R. (Concrete)
QVF Ltd (Glass)
Randall Ltd, P. E. (lead)
Rediweld Ltd (Plastics)
Research & Control Instruments Ltd
Rolls-Royce Ltd
Savage & Parsons Ltd (Concrete, Lead)
Simon-Carves Ltd (Concrete)
United Chemicals (London) Ltd (Barytes Bricks)
Western Detail Mfrs Ltd (Lead)

SHIELDING—THERMAL
★ Circle *No 481* on reply card
Babcock & Wilcox Ltd
Beardmore & Co Ltd, William
Chatwood-Milner Ltd
Darlington Insulation Co Ltd, The
English Steel Corporation Ltd
Grey & Marten Ltd
Hadfields Ltd
International Mechanite Metal Co Ltd, The
Mallinson & Sons Ltd, William
Metal Propellers Ltd
Nuclear Engineering Ltd
Pilkington Bros Ltd
Rolls-Royce Ltd
Simon-Carves Ltd
Thompson Ltd, John
Western Detail Mfrs Ltd

SOLVENT RECOVERY PLANT
★ Circle *No 482* on reply card
Apex Construction Ltd
Hall & Co Ltd, Matthew
QVF Ltd
Simon-Carves Ltd

SOLVENTS
★ Circle *No 483* on reply card
British Industrial Solvents Ltd
Geigy Co Ltd, The
General Chemical & Pharmaceutical Co Ltd, The
Heat Transfer Ltd
Howards of Ilford Ltd
Imperial Chemical Industries Ltd
Shell Chemical Co Ltd

SOUNDPROOFING
★ Circle *No 484* on reply card
Burgess Products Co Ltd
Chatwood-Milner Ltd
Keith Blackman Ltd
Newalls Insulation Co Ltd

SPEED REDUCERS
★ Circle *No 485* on reply card
Armstrong Whitworth (Met. Ind.) Ltd
British Thomson-Houston Co Ltd, The
Brown Corporation Ltd, The David
Fenner & Co Ltd, J. H.
Freeman, Taylor Machines Ltd
Opperman Gears Ltd
Sanderson Bros & Newbould Ltd
Varatio-Strateline Gears Ltd
Weyers Bros Ltd

SPRINGS
★ Circle *No 486* on reply card
Anderton Springs Ltd
Brockhouse & Co Ltd, J.
Cary Ltd, Wm. E.
English Steel Corp Ltd
Fox & Co Ltd, Samuel
Hewell Spring Co Ltd
Hindle & Sons Ltd
Steel, Peech & Tozer
United Spring Co, The
United Steel Companies Ltd, The

STEEL—BARS
★ Circle *No 487* on reply card
Allen & Co Ltd, Edgar
Appleby-Frodingham Steel Co
Bairds & Scottish Steel Ltd
Beardmore & Co Ltd, William
Darwins Ltd
English Steel Corp Ltd
English Steel Forge & Engineering Corp Ltd
Firth & John Brown Ltd, Thomas
Fox & Co Ltd, Samuel
Gardner & Co Ltd, Henry
Hadfields Ltd
Jessop & Sons Ltd, William
Lee & Sons Ltd, Arthur
Low Moor Alloy Steelworks Ltd
Moss & Gamble Bros Ltd
Osborne & Co Ltd, Samuel
Rigby & Sons Ltd, John
Sanderson Bros & Newbould Ltd
Steel Co of Wales Ltd, The
Steel, Peech & Tozer
Talbot Stead Tube Co Ltd
Thomas & Baldwins Ltd, Richard
TI Nuclear Engineering Ltd
United Steel Companies Ltd, The

STEEL—CASTINGS
★ Circle *No 488* on reply card
Allen & Co Ltd, Edgar
APV Co Ltd, The
Armstrong Siddeley Motors Ltd
Armstrong Whitworth (Met. Ind.) Ltd
Ashwell & Nesbit Ltd
Beardmore & Co Ltd, William
Brockhouse & Co Ltd, J.
Clay Cross (Iron & Foundries) Ltd
Darwins Ltd
Distington Engineering Co Ltd
English Electric Co Ltd, The
English Steel Corp Ltd
English Steel Forge & Engineering Corp Ltd
Firth & John Brown Ltd, Thomas
Follsain-Wycliffe Foundries Ltd (Heat Resisting)
Fowler & Co (Leeds) Ltd, John
Grazebrook Ltd, M. & W.
Hadfields Ltd

STEEL CASTINGS—*continued*
Head Wrightson & Co Ltd (Nuclear Power Div)
Jessop & Sons Ltd, William
K & L Steelfounders & Engineers Ltd
Langley Alloys Ltd
Lloyd & Co Ltd, F. H.
Millspaugh Ltd
Osborne & Co Ltd, Samuel
Shaw Glasgow Ltd
Thomas & Baldwins Ltd, Richard
Thompson Castings Ltd, John
United Steel Companies Ltd, The

STEEL—FORGINGS
★ Circle *No 489* on reply card
Brockhouse & Co Ltd, J.
Darwins Ltd
Beardmore & Co Ltd, William
English Steel Corp Ltd
English Steel Forge & Engineering Corp Ltd
Firth & John Brown Ltd, Thomas
Hadfields Ltd
Head Wrightson & Co Ltd (Nuclear Power Div)
Jessop & Sons Ltd, William
Moore & Co Ltd, W. & E.
Moss & Gamble Bros Ltd
Osborn & Co Ltd, Samuel
Steel Peech & Tozer
Thomas & Baldwins Ltd, Richard
United Steel Companies Ltd, The

STEEL—PLATES
★ Circle *No 490* on reply card
Allen & Co Ltd, Edgar
Appleby-Frodingham Steel Co
English Steel Corp Ltd
English Steel Forge & Engineering Corp Ltd
Firth & John Brown Ltd, Thomas
Fox & Co Ltd, Samuel
Gardner & Co Ltd, Henry
Gardner & Co Ltd, J.
General Steel Group
Hadfields Ltd
Low Moor Alloy Steelworks Ltd
Osborn & Co Ltd, Samuel
Steel Co of Wales Ltd, The
Steel, Peech & Tozer
Thomas & Baldwins Ltd, Richard
United Steel Companies Ltd, The
Watson & Co Ltd, Robert

STEEL—SECTIONS
★ Circle *No 491* on reply card
Allen & Co Ltd, Edgar
Appleby-Frodingham Steel Co
Bairds & Scottish Steel Ltd
Brockhouse & Co Ltd, J.
Darwins Ltd
English Steel Forge & Engineering Corp Ltd
Firth & John Brown Ltd, Thomas
Gardner & Co Ltd, Henry
General Steel Group
Low Moor Alloy Steelworks Ltd
Osborne & Co Ltd, Samuel
Rigby & Sons Ltd, John
Southborough (Weybridge) Ltd
TI Nuclear Engineering Ltd
United Steel Companies Ltd, The
Watson & Co Ltd, Robert

STEEL—STAMPINGS
★ Circle *No 492* on reply card
Braby & Co Ltd, Fredr.
English Steel Corp Ltd
English Steel Forge & Engineering Corp Ltd
Firth & John Brown Ltd, Thomas
Jessop & Sons Ltd, William
Southborough (Weybridge) Ltd
United Steel Companies Ltd, The
Wilmot Breeden Ltd

STEEL—STRIP
★ Circle *No 493* on reply card
English Steel Forge & Engineering Corp Ltd
Fox & Co Ltd, Samuel
Gardner & Co Ltd, Henry
General Steel Group
Lancashire & Corby Steel Mfg Co Ltd
Lee & Sons Ltd, Arthur
Low Moor Alloy Steelworks Ltd
Osborn & Co Ltd, Samuel
Sanderson Bros & Newbould Ltd
Steel Co of Wales Ltd, The
Steel, Peech & Tozer
Thomas & Baldwins Ltd, Richard
United Steel Companies Ltd, The

STIRRING GEAR
★ Circle *No 494* on reply card
Aiton & Co Ltd
Apex Construction Ltd
Ashworth & Parker Ltd
Balfour & Co Ltd, Henry
Blundell & Crompton Ltd
Butterfield Ltd, W. P.
Chatwood-Milner Ltd
Davey, Paxman & Co Ltd
Fraser & Co Ltd, W. J.
Freeman, Taylor Machines Ltd
Globe Pneumatic Eng Co Ltd
Harris (Birmingham) Ltd, F. & R. M.
Horseley Bridge & Thomas Piggott Ltd
Lang London Ltd
Metal Propellers Ltd
Nuclear Engineering Ltd
QVF Ltd

STRAINERS—CHEMICAL
★ Circle *No 495* on reply card
Ashworth & Parker Ltd
Brackett & Co Ltd, F. W.
Endecotts (Filters) Ltd
Plenty & Son Ltd
Simmons & Hawker Ltd

STRAINERS—OIL
★ Circle *No 496* on reply card
Ashworth & Parker Ltd
Bailey & Co Ltd, Sir W. H.
Brackett & Co Ltd, F. W.

STRAINERS—OIL—*continued*
Endecotts (Filters) Ltd
Hindle & Sons Ltd, Joshua
Liquid Systems Ltd
Madan & Co Ltd, Charles S.
Plenty & Son Ltd
Simmons & Hawker Ltd

STRAINERS—STEAM
★ Circle *No 497* on reply card
Bailey & Co Ltd, Sir W. H.
Brackett & Co Ltd, F. W.
British Steam Specialties Ltd
Hindle & Sons Ltd, Joshua
Madan & Co Ltd, Charles S.

STRAINERS—WATER
★ Circle *No 498* on reply card
Ashworth & Parker Ltd
Bailey & Co Ltd, Sir W. H.
Brackett & Co Ltd., F. W.
Endecotts (Filters) Ltd
Hindle & Sons Ltd, Joshua
Madan & Co Ltd, Charles S.
Plenty & Son Ltd

SUPERHEATERS
★ Circle *No 499* on reply card
Adamson, Daniel, & Co Ltd
Babcock & Wilcox Ltd
Birwelco Ltd
Chesterfield Tube Co Ltd, The
Clarke, Chapman & Co Ltd
Foster Wheeler Ltd
General Electric Co Ltd, The
International Combustion Ltd
Simon-Carves Ltd
Stewarts & Lloyds Ltd
Superheater Co Ltd, The
Thompson Water Tube Boilers Ltd, John
Thompson (Wolverhampton) Ltd, John
Unit Superheater & Pipe Co Ltd
Yarrow & Co Ltd

SWITCHGEAR—CONTACTOR
★ Circle *No 500* on reply card
AEW Ltd
British Thomson-Houston Co Ltd, The
Brookhirst Switchgear Ltd
Donovan Electrical Co Ltd
Electric Construction Co Ltd, The
EMB Ltd
Geipel Ltd, William
General Electric Co Ltd, The
Hendrey Relays Ltd
Klockner-Moeller Ltd
Lancashire Dynamo Nevelin Ltd
Laurence, Scott & Electromotors Ltd
Metropolitan-Vickers Electrical Co Ltd
Midland Electrical Mfg Co Ltd
Plessey Nucleonics Ltd
Reyrolle & Co Ltd, A.
Siemens Edison Swan Ltd
Universal Control Equipment Ltd

SWITCHGEAR—h.t.
★ Circle *No 501* on reply card
ASEA Electric Ltd
British Thomson-Houston Co Ltd, The
Brookhirst Switchgear Ltd
Crompton Parkinson Ltd
Electric Construction Co Ltd, The
Ellison Ltd, George
English Electric Co Ltd, The
Ferguson Pailin Ltd
Ferranti Ltd
General Electric Co Ltd, The
Harland & Wolff Ltd
Ionic Instruments (London) Ltd
Johnson & Phillips Ltd
Lancashire Dynamo & Crypto Ltd
Nuclear Power Plant Co Ltd, The
Reyrolle & Co Ltd, A.
Siemens Edison Swan Ltd
Thermocontrol Installations Co Ltd
Tube Investments Ltd
Victor Products (Wallsend) Ltd

SWITCHGEAR—l.t.
★ Circle *No 502* on reply card
ASEA Electric Ltd
Austinlite Ltd
Belmos Co Ltd, The
British Thomson-Houston Co Ltd, The
Brookhirst Switchgear Ltd
Crompton Parkinson Ltd
Electric Construction Co Ltd, The
Ellison Ltd, George
English Electric Co Ltd, The
Ferguson Pailin Ltd
Ferranti Ltd
General Electric Co Ltd, The
GWB Furnaces Ltd
Ionic Instruments (London) Ltd
Johnson & Phillips Ltd
Klockner Moeller England Ltd
Lancashire Dynamo Nevelin
Laurence, Scott & Electromotors Ltd
Nuclear Power Plant Co Ltd, The
Ottermill Switchgear Ltd
Reyrolle & Co Ltd, A.
Salford Electrical Instruments Ltd
Siemens Edison Swan Ltd
Simplex Electric Co Ltd
Thermocontrol Installations Co Ltd
TI Nuclear Engineering Ltd
Victor Products (Wallsend) Ltd
Whipp & Bourne Ltd

TABLET MACHINES
★ Circle *No 503* on reply card
Apex Construction Ltd
Manesty Machines Ltd
Motherwell Bridge & Engineering Co Ltd, The

TANKS OR VESSELS
★ Circle *No 504* on reply card
Aiton & Co Ltd
Allen & Sons (Tipton) Ltd, W. G. (Steel and Aluminium Alloy)
Almin Ltd

TANKS OR VESSELS—*continued*
Apex Construction Ltd
APV Co Ltd, The
Ashmore, Benson, Pease & Co (Non-ferrous)
Babcock & Wilcox Ltd
Balfour & Co Ltd, Henry
Bawn & Co Ltd, W. B.
Bennett Sons & Shears Ltd
Birmingham & Blackburn Construction Co Ltd (Mild and Stainless Steel)
Birwelco Ltd (Steel)
Blundell & Crompton Ltd
Braby & Co Ltd, Fredr. (All Types)
British Industrial Engineering Co (Staffs) Ltd (All Types)
Butterfield Ltd, W. P. (Mild and Stainless Steel; Nickel and Nickel Alloy; Aluminium and Aluminium alloy)
Callow (Engineers) Ltd, F. E.
Carlson Ltd, John D.
Chatwood-Milner Ltd (Lead Lined)
Clarke, Chapman & Co Ltd
Darham Industries (London) Ltd
Davey, Paxman & Co Ltd
Doulton Industrial Porcelains Ltd (Stoneware)
Dunlop Rubber Co Ltd
Extrudex Ltd (Plastic)
Foster Wheeler Ltd
Foster Yates & Thom Ltd (Mild Steel)
Fraser & Co Ltd, W. J.
Freeman, Taylor Machines Ltd (Stainless and Mild Steel)
General Steel Group (Steel)
Grazebrook Ltd, M. & W. (Mild and Stainless Steel; Aluminium)
Grey & Marten Ltd (All Metals-Galvanized)
Hargreaves & Sons Ltd, Henry
Harris (Birmingham) Ltd, F. & R. M. (All Metals)
Harvey & Co (London) Ltd, G. A.
Hathermware Ltd (Stoneware)
Horseley Bridge & Thomas Piggott Ltd
Jenkins & Co Ltd, Robert
Lang London Ltd
Liquid Systems Ltd (Mild Steel)
Marston Excelsior Ltd (Aluminium)
Mason (Chemical Engineers) Ltd, G. Samuel (All Types)
Mechans Ltd
Mendip (Chemical Engineering) Ltd (Reinforced Plastics)
Metal Propellers Ltd
Millspaugh Ltd
Mills Packard Construction Co Ltd (Steel)
Moore & Co Ltd, W. & E
Motherwell Bridge & Engineering Co Ltd
Napier & Son Ltd, D.
Newton, Chambers & Co Ltd (Steel)
Nuclear Engineering Ltd
Palatine Tool & Engineering Co (Surbiton) Ltd (Stainless Steel)
Power-Gas Corporation Ltd, The
QVF Ltd (Glass)
Robertson & Ferguson Ltd (Steel)
Robey & Co Ltd (Steel)
Ruston & Hornsby Ltd (Ferrous and Non-Ferrous)
Rye-Arc Ltd
Ryder & Co (Manchester) Ltd, Thos.
Simmons & Hawker Ltd (Mild Steel)
Simon-Carves Ltd
Southborough (Weybridge) Ltd (Stainless Steel)
Stainless Steel Vessels (London) Ltd
Steels Engineering Installations Ltd
Thermo-Plastics Ltd
Thermal Syndicate Ltd, The (Vitreosil)
Thompson (Dudley) Ltd, John (Steel)
Thompson (Wolverhampton) Ltd, John (Steel)
Vicsons Ltd
Walker Ltd, C. & W.
Ward Ltd, Thos. W.
Widnes Foundry & Engineering Co Ltd (Steel)
Wilkinson Rubber Linatex Ltd
Windshields of Worcester Ltd
Wright, Anderson & Co Ltd (Steel)
Yorkshire Engineering & Welding Co Ltd

TESTING SERVICES—NON-DESTRUCTIVE
★ Circle *No 505* on reply card
Andrews & Platt (Engineers) Ltd
BTR Industries Ltd
Cawkell, Research & Electronics Ltd
CNS Instruments Ltd
Falk & Co Ltd, M.
Hawker Siddeley Nuclear Power Co Ltd.
Industrial Radiography (NDT) Ltd
Madan & Co Ltd, Charles S.
Metropolitan-Vickers Electrical Co Ltd
Motherwell Bridge & Engineering Co Ltd
Newton Victor Ltd
Pantak Ltd
Unit Superheater & Pipe Co Ltd
Welding Supervision Ltd

TRANSFORMERS—h.t.
★ Circle *No 506* on reply card
ASEA Electric Ltd
British Thomson-Houston Co Ltd, The
Brush Group Ltd, The
Bryce Electrical Construction Co Ltd
Crompton Parkinson Ltd
Darlington Insulation Co Ltd, The
Electric Construction Co Ltd, The
English Electric Co Ltd, The
Ferranti Ltd
Fuller Electric Ltd
General Electric Co Ltd, The
Gresham Transformers Ltd
Hackbridge & Hewittic Electric Co Ltd
Johnson & Phillips Ltd
London Transformer Products Ltd
Metropolitan-Vickers Electrical Co Ltd
Nuclear Power Plant Co Ltd, The
Parsons & Co Ltd, C. A.

TRANSFORMERS—l.t.
★ Circle *No 507* on reply card
ASEA Electric Ltd
British Thomson-Houston Co Ltd, The
Bryce Electrical Construction Co Ltd
Crompton Parkinson Ltd

TRANSFORMERS—l.t.—*continued*
Electric Construction Co Ltd, The
English Electric Co Ltd, The
Ferranti Ltd
Fuller Electric Ltd
General Electric Co Ltd, The
Gresham Transformers Ltd
Johnson & Phillips Ltd
London Transformer Products Ltd
Metropolitan-Vickers Electrical Co Ltd
Nuclear Power Plant Co Ltd, The
Parsons & Co Ltd, C. A.
Plessey Nucleonics Ltd
Standard Telephones & Cables Ltd

TRANSPORT FLASKS (COFFINS)
★ Circle *No 508* on reply card
Chatwood-Milner Ltd
Cravens Ltd
Dewrance & Co Ltd, Metal
International Meehanite Metal Co Ltd, The
Jenkins & Co Ltd, Robert
QVF Ltd
Robey & Co Ltd
Western Detail Mfrs Ltd

TRAPS—STEAM
★ Circle *No 509* on reply card
Aiton & Co Ltd
Babcock & Wilcox Ltd
British Steam Specialties Ltd
Cockburns Ltd
Dewrance & Co Ltd
Heat Transfer Ltd
Hopkins & Co Ltd, F.
Hopkinsons Ltd
Ryder & Co (Manchester) Ltd, Thomas
Stokes, Taylor & Shaw Ltd
United States Metallic Packing Co Ltd

TUBING *(See Piping)*

TUBING—EXTENDED SURFACE
★ Circle *No 510* on reply card
Accles & Pollock Ltd (All Types)
British Ermeto Corporation Ltd (All Types)
Clarke, Chapman & Co Ltd (Finned & Gilled in Mild Steel)
Imperial Chemical Industries Ltd (All Types)
Kirk & Co (Tubes) Ltd (All Types)
Northern Aluminium Co Ltd (Aluminium—Finned)
Richards & Ross Ltd (Steel—Helical Finned)
Spiro-Gills Ltd (Ferrous & Non-Ferrous, Helical Gills or Plate Fins)
Standard & Pochin Bros Ltd (Copper, Steel & Aluminium, Gilled)
TI Nuclear Engineering Ltd (Aluminium & Magnesium Alloys; Steel)

TURBINES—GAS
★ Circle *No 511* on reply card
Adamson & Co Ltd, Daniel
Allen Sons & Co Ltd, W. H.
ASEA Electric Ltd
Bristol Aero-Engines Ltd
British Thomson-Houston Co Ltd, The
Brown Land Boilers Ltd, John
Budworth Ltd, David
English Electric Co Ltd, The
Harland & Wolff Ltd
Metropolitan-Vickers Electrical Co Ltd
Nuclear Power Plant Co Ltd, The
Parsons & Co Ltd, C. A.
Ruston & Hornsby Ltd

TURBINES—STEAM
★ Circle *No 512* on reply card
Allen Sons & Co Ltd, W. H.
ASEA Electric Ltd
Belliss & Morcom Ltd
British Thomson-Houston Co Ltd, The
Brotherhood Ltd, Peter
Budworth Ltd, David
English Electric Co Ltd, The
Firth Brown Ltd
General Electric Co Ltd, The
Harland & Wolff Ltd
Hayward Tyler & Co Ltd
Howden & Co Ltd, James
Nuclear Power Plant Co Ltd, The
Parsons & Co Ltd, C. A.
Richardsons Westgarth Ltd
Weir Ltd, G. & J.

ULTRASONIC INSPECTION EQUIPMENT
★ Circle *No 513* on reply card
Falk & Co Ltd, M.
Industrial Radiography (NDT) Ltd
Kelvin & Hughes (Industrial) Ltd
Ultrasonoscope Co (London) Ltd
Welding Supervision Ltd

VACUUM CLEANERS—INDUSTRIAL
★ Circle *No 514* on reply card
Bivac Air Co Ltd (fixed and portable)
Mancuna Engineering Ltd
Service Electric Co Ltd
Sturtevant Engineering Co Ltd

VACUUM PLANT *(See Section 2)*

VALVES (BY TYPE)—ANGLE
★ Circle *No 515* on reply card
Appleby & Ireland Ltd
Babcock & Wilcox Ltd
Bailey & Co Ltd, Sir W. H.
British Ermeto Corporation Ltd
British Steam Specialties Ltd
Dewrance & Co Ltd
Gordon & Co Ltd, James
Hindle & Sons Ltd, Joshua
Hopkinsons Ltd
Inness & Co (Darlington) Ltd
Newman, Hender & Co Ltd
Perfection Parts Ltd
Ryder & Co (Manchester) Ltd, Thomas
Saunders Valve Co Ltd
Thermocontrol Installations Co Ltd
Warren, Morrison Ltd
Weir Valves Ltd

VALVES (BY TYPE)—BALANCED DISK
★ Circle *No 516* on reply card
Appleby & Ireland Ltd
Bailey & Co Ltd, Sir W. H.
Boving & Co Ltd
Glenfield & Kennedy Ltd
Gordon & Co Ltd, James
Hopkinsons Ltd
Ryder & Co (Manchester) Ltd, Thomas
Thermocontrol Installations Co Ltd

VALVES (BY TYPE)—BELLOWS SEALED
★ Circle *No 517* on reply card
Alexander Controls Ltd
Appleby & Ireland Ltd
Armstrong Siddeley Motors Ltd
Babcock & Wilcox Ltd
British Ermeto Corporation Ltd
Dewrance & Co Ltd
Elliott Bros (London) Ltd
Glenfield & Kennedy Ltd
Gordon & Co Ltd, James
Inness & Co (Darlington) Ltd
IV Pressure Controllers Ltd
Newman, Hender & Co Ltd
Palatine Tool & Engineering Co Ltd
Ryder & Co (Manchester) Ltd, Thomas
Teddington Industrial Equipment Ltd
Thermocontrol Installations Co Ltd
Vacuum Industrial Applications Ltd
Western Detail Mfrs Ltd

VALVES (BY TYPE)—DIAPHRAGM SEALED
★ Circle *No 518* on reply card
Alexander Controls Ltd
Appleby & Ireland Ltd
Ellison Ltd, George
Gordon & Co Ltd, James
IV Pressure Controllers Ltd
Metro-Flex Atomic Engineering Ltd
Perfection Parts Ltd
Ryder & Co (Manchester) Ltd, Thomas
Saunders Valve Co Ltd
Thermocontrol Installations Co Ltd
Vacuum Industrial Applications Ltd
Warren Morrison Ltd
Western Detail Mfrs Ltd

VALVES—GLOBE
★ Circle *No 519* on reply card
Appleton & Howard Ltd
APV Co Ltd, The
Babcock & Wilcox Ltd
Bailey & Co Ltd, Sir W. H.
British Steam Specialties Ltd
Dewrance & Co Ltd
Glenfield & Kennedy Ltd
Hindle & Sons Ltd, Joshua
Hopkinsons Ltd
Inness & Co (Darlington) Ltd
IV Pressure Controllers Ltd
Kirk & Co (Tubes) Ltd
Langley Alloys Ltd
Newman, Hender & Co Ltd
Ryder & Co (Manchester) Ltd
Taylor Controls Ltd
Weir Valves Ltd

VALVES—MIXING
★ Circle *No 520* on reply card
Gordon & Co Ltd, James
Hindle & Sons Ltd, Joshua
Kirk & Co (Tubes) Ltd
Ryder & Co (Manchester) Ltd, Thomas
Thermocontrol Installations Co Ltd

VALVES—NEEDLE
★ Circle *No 521* on reply card
Alexander Controls Ltd
Appleby & Ireland Ltd
Appleton & Howard Ltd
Babcock & Wilcox Ltd
Baldwin Instrument Co Ltd
British Ermeto Corporation Ltd
British Steam Specialties Ltd
Dewrance & Co Ltd
Edwards High Vacuum Ltd
Glenfield & Kennedy Ltd
Gordon & Co Ltd, James
Hindle & Sons Ltd, Joshua
Hopkinsons Ltd
Inness & Co (Darlington) Ltd
IV Pressure Controllers Ltd
Kirk & Co (Tubes) Ltd
Langley Alloys Ltd
Leybold Vacuum Sales Ltd
Martonair Ltd
Milne & Co Ltd, C. S.
Newman, Hender & Co Ltd
Palatine Tool & Engineering Co (Surbiton) Ltd
Ryder & Co (Manchester) Ltd, Thomas
Spembly Ltd
Vacuum Industrial Applications Ltd
Weir Valves Ltd
Western Detail Mfrs Ltd
Williams & James (Engineers) Ltd

VALVES—NON RETURN
★ Circle *No 522* on reply card
Alexander Controls Ltd
Appleton & Howard Ltd
Babcock & Wilcox Ltd
Bailey & Co Ltd, Sir W. H.
Baldwin Instrument Co Ltd
Ben Patents Ltd
British Ermeto Corporation Ltd
British Steam Specialties Ltd
Dewrance & Co Ltd
Edwards High Vacuum Ltd
Electro-Hydraulics Ltd
Ellison Ltd, George
Glenfield & Kennedy Ltd
Ham, Baker & Co Ltd
Harland Engineering Co Ltd
High Pressure Components Ltd
Hopkinsons Ltd
Inness & Co (Darlington) Ltd
Integral Ltd
IV Pressure Controllers Ltd
Kirk & Co (Tubes) Ltd
Madan & Co Ltd, Charles S

VALVES—NON RETURN—*continued*
Martonair Ltd
Milne & Co Ltd, C. S.
Newman, Hender & Co Ltd
Perfection Parts Ltd
QVF Ltd
Ryder & Co (Manchester) Ltd, Thomas
Spembly Ltd
Telehoist Ltd
Thermocontrol Installations Co Ltd
Towler Bros (Patents) Ltd
Weir Valves Ltd
Western Detail Mfrs Ltd
Williams & James (Engineers) Ltd

VALVES—PARALLEL SLIDE
★ Circle *No 523* on reply card
Appleby & Ireland Ltd
Babcock & Wilcox Ltd
Bailey & Co Ltd, Sir W. H.
Blakeborough & Sons Ltd, J.
British Steam Specialties Ltd
Cockburns Ltd
Dewrance & Co Ltd
Electro-Hydraulics Ltd
Glenfield & Kennedy Ltd
Ham, Baker & Co Ltd
Harland Engineering Co Ltd
Hindle & Sons Ltd, Joshua
Hopkinsons Ltd
Inness & Co (Darlington) Ltd
IV Pressure Controllers Ltd
Kirk & Co (Tubes) Ltd
Newman, Hender & Co Ltd
QVF Ltd
Ryder & Co (Manchester) Ltd, Thomas
Weir Valves Ltd

VALVES—PISTON
★ Circle *No 524* on reply card
Alexander Controls Ltd
Baldwin Instrument Co Ltd
Globe Pneumatic Eng Co Ltd
High Pressure Components Ltd
Hindle & Sons Ltd, Joshua
Integral Ltd
Klinger Ltd, Richard
Leybold Vacuum Sales Ltd
Martonair Ltd
Newman, Hender & Co Ltd
Palatine Tools & Engineering Co (Surbiton) Ltd
Ryder & Co (Manchester) Ltd, Thomas
Telehoist Ltd
Towler Bros (Patents) Ltd

VALVES—PLUG
★ Circle *No* 525 on reply card
Appleton & Howard Ltd
British Ermeto Corporation Ltd
British Steam Specialties Ltd
Elliott Bros (London) Ltd
Extrudex Ltd
Glenfield & Kennedy Ltd
Globe Pneumatic Eng Co Ltd
Gordon & Co Ltd, James
Harland Engineering Co Ltd
Hathernware Ltd
High Pressure Components Ltd
Hindle & Sons Ltd, Joshua
Inness & Co (Darlington) Ltd
IV Pressure Controllers Ltd
Kirk & Co (Tubes) Ltd
Klinger Ltd, Richard
Newman, Hender & Co Ltd
QVF Ltd
Ryder & Co (Manchester) Ltd, Thomas
Saunders Valve Co Ltd
TI Nuclear Engineering Ltd
Warren Morrison Ltd

VALVES—REDUCING
★ Circle *No 526* on reply card
Aerospray Associated Ltd
Bailey & Co Ltd, Sir W. H.
Baldwin Instrument Co Ltd
Ben Patents Ltd
Bennett Sons & Shears Ltd
British Steam Specialties Ltd
Cockburns Ltd
Crosby Valve & Engineering Co Ltd
Dewrance & Co Ltd
Electro-Hydraulics Ltd
Elliott Bros (London) Ltd
Ellison Ltd, George
Glenfield & Kennedy Ltd
Globe Pneumatic Eng Co Ltd
Gordon & Co Ltd, James
Harland Engineering Co Ltd
High Pressure Components Ltd
Hindle & Sons Ltd, Joshua
Hopkinsons Ltd
Inness & Co (Darlington) Ltd
IV Pressure Controllers Ltd
Kirk & Co (Tubes) Ltd
Madan & Co Ltd, Charles S.
Milne & Co Ltd, C. S.
Newman, Hender & Co Ltd
Norgren Ltd, C. A.
Ryder & Co (Manchester) Ltd, Thomas
Thermocontrol Installations Co Ltd
Towler Bros (Patents) Ltd
Williams & James (Engineers) Ltd

VALVES—RELIEF
★ Circle *No 527* on reply card
Appleby & Ireland Ltd
APV Co Ltd, The
Babcock & Wilcox Ltd
Bailey & Co Ltd, Sir W. H.
Ben Patents Ltd
Blundell & Crompton Ltd
British Steam Specialties Ltd
Cockburns Ltd
Crosby Valve & Engineering Co Ltd
Dewrance & Co Ltd
Electro-Hydraulics Ltd
Ellison Ltd, George
Glenfield & Kennedy Ltd
Gordon & Co Ltd, James
Harland Engineering Co Ltd
High Pressure Components, Ltd

VALVES—RELIEF—*continued*
Hindle & Sons Ltd, Joshua
Hopkinsons Ltd
Inness & Co (Darlington) Ltd
Integral Ltd
IV Pressure Controllers Ltd
Kirk & Co (Tubes) Ltd
Madan & Co Ltd, Charles S.
Milne & Co Ltd, C. S.
Newman, Hender & Co Ltd
QVF Ltd
Ryder & Co (Manchester) Ltd, Thomas
Telehoist Ltd
Towler Bros (Patents) Ltd
Williams & James (Engineers) Ltd

VALVES—SAFETY
★ Circle *No 528* on reply card
Aerospray Associated Ltd
Alexander Controls Ltd
Appleby & Ireland Ltd
Babcock & Wilcox Ltd
Bailey & Co Ltd, Sir W. H.
Ben Patents Ltd
Blundell & Crompton Ltd
British Steam Specialties Ltd
Cockburns Ltd
Crosby Valve & Engineering Co Ltd
Dewrance & Co Ltd
Electro-Hydraulics Ltd
Harland Engineering Co Ltd
Hindle & Sons Ltd, Joshua
Hopkinsons Ltd
Inness & Co (Darlington) Ltd
IV Pressure Controllers Ltd
Kirk & Co (Tubes) Ltd
Madan & Co Ltd, Charles S.
Newman, Hender & Co Ltd
Ryder & Co (Manchester) Ltd, Thomas
Telehoist Ltd
Thermocontrol Installations Co Ltd
Williams & James (Engineers) Ltd

VALVES—SLUICE
★ Circle *No 529* on reply card
Appleton & Howard Ltd
Bailey & Co Ltd, Sir W. H.
Blakeborough & Sons Ltd, J.
British Steam Specialties Ltd
Glenfield & Kennedy Ltd
Ham, Baker & Co Ltd
Harland Engineering Co Ltd
Hindle & Sons Ltd, Joshua
Hopkinsons Ltd
Howden & Co Ltd, James
Inness & Co (Darlington) Ltd
IV Pressure Controllers Ltd
Kirk & Co (Tubes) Ltd
Newman, Hender & Co Ltd
Ryder & Co (Manchester) Ltd, Thomas

VALVES—WEDGE GATE
★ Circle *No 530* on reply card
Appleton & Howard Ltd
Bailey & Co Ltd, Sir W. H.
Blakeborough & Sons Ltd, J.
British Ermeto Corporation Ltd
British Steam Specialties Ltd
Glenfield & Kennedy Ltd
Ham, Baker & Co Ltd
Hindle & Sons Ltd, Joshua
Hopkinsons Ltd
Inness & Co (Darlington) Ltd
IV Pressure Controllers Ltd
Langley Alloys Ltd
Newman, Hender & Co Ltd
Ryder & Co (Manchester) Ltd, Thomas
Weir Valves Ltd

VALVES (BY OPERATION)—DIAPHRAGM
★ Circle *No 531* on reply card
Appleby & Ireland Ltd
Babcock & Wilcox Ltd
Baldwin Instrument Co Ltd
British Steam Specialties Ltd
Crosby Valve & Engineering Co Ltd
Edwards High Vacuum Ltd
Elliott Bros (London) Ltd
Ellison Ltd, George
Gordon & Co Ltd, James
Inness & Co (Darlington) Ltd
IV Pressure Controllers Ltd
Martonair Ltd
Ryder & Co (Manchester) Ltd, Thomas
Saunders Valve Co Ltd
Talbot Stead Tube Co Ltd
Thermocontrol Installations Co Ltd
TI Nuclear Engineering Ltd
Warren Morrison Ltd
Western Detail Mfrs Ltd

VALVES (BY OPERATION)—ELECTRIC MOTOR
★ Circle *No 532* on reply card
Appleby & Ireland Ltd
Babcock & Wilcox Ltd
Bailey & Co Ltd, Sir W. H.
Blakeborough & Sons Ltd, J.
British Steam Specialties Ltd
Cockburns Ltd
Dewrance & Co Ltd
Ellison Ltd, George
Firkins Ltd, G. & A.
Glenfield & Kennedy Ltd
Gordon & Co Ltd, James
Ham, Baker & Co Ltd
Harland Engineering Co Ltd
Hindle & Sons Ltd, Joshua
Hopkins & Co Ltd, F.
Hopkinsons Ltd
Inness & Co (Darlington) Ltd
IV Pressure Controllers Ltd
Kent Ltd, George
Leybold Vacuum Sales Ltd
Martonair Ltd
Metro-Flex Atomic Engineering Ltd
N.G.N. Electrical Ltd
Newman, Hender & Co Ltd
Ryder & Co (Manchester) Ltd, Thomas
Saunders Valve Co Ltd
Stonebridge Electrical Co Ltd
Teddington Industrial Equipment Ltd
Thermocontrol Installations Co Ltd
Western Detail Mfrs Ltd

VALVES (BY OPERATION)—HYDRAULIC
★ Circle *No 533* on reply card
Alexander Controls Ltd
Bailey & Co Ltd, Sir W. H.
Chamberlain Industries Ltd
Crosby Valve & Engineering Co Ltd
Electro-Hydraulics Ltd
Ellison Ltd, George
Glenfield & Kennedy Ltd
Gordon & Co Ltd, James
Harland Engineering Co Ltd
Inness & Co (Darlington) Ltd
Integral Ltd
IV Pressure Controllers Ltd
Klinger Ltd, Richard
Martonair Ltd
Metro-Flex Atomic Engineering Ltd
Newman, Hender & Co Ltd
Ryder & Co (Manchester) Ltd, Thomas
Saunders Valve Co Ltd
Short Bros & Harland Ltd
Telehoist Ltd
Towler Bros (Patents) Ltd
United States Metallic Packing Co Ltd
Warren Morrison Ltd

VALVES (BY OPERATION)—PNEUMATIC
★ Circle *No 534* on reply card
Alexander Controls Ltd
Appleby & Ireland Ltd
Bailey & Co Ltd, Sir W. H.
Crosby Valve & Engineering Co Ltd
Dewrance & Co Ltd
Electro-Hydraulics Ltd
Ellison Ltd, George
Glenfield & Kennedy Ltd
Globe Pneumatic Eng Co Ltd
Gordon & Co Ltd, James
Harland Engineering Co Ltd
Inness & Co (Darlington) Ltd
IV Pressure Controllers Ltd
Klinger Ltd, Richard
Lang Pneumatic Ltd
Leybold Vacuum Sales Ltd
Martonair Ltd
Metro-Flex Atomic Engineering Ltd
Newman, Hender & Co Ltd
Ryder & Co (Manchester) Ltd, Thomas
Saunders Valve Co Ltd
United States Metallic Packing Co Ltd
Warren Morrison Ltd

VALVES (BY OPERATION)—SOLENOID
★ Circle *No 535* on reply card
Alexander Controls Ltd
Appleby & Ireland Ltd
Baldwin Instrument Co Ltd
Babcock & Wilcox Ltd
Cockburns Ltd
Dewrance & Co Ltd
Edwards High Vacuum Ltd
Electro-Hydraulics Ltd
Ellison Ltd, George
Globe Pneumatic Eng Co Ltd
Harland Engineering Co Ltd
Inness & Co (Darlington) Ltd
IV Pressure Controllers Ltd
Jones & Stevens Ltd
Lang Pneumatic Ltd
Lock & Co Ltd, A. M.
Magnetic Equipment Co Ltd, The
Magnetic Valve Co Ltd, The
Martonair Ltd
Newman, Hender & Co Ltd
Perfection Parts Ltd
Pulsometer Engineering Co Ltd, The
Ryder & Co (Manchester) Ltd, Thomas
Teddington Industrial Equipment Ltd
Telehoist Ltd
Thermocontrol Installations Co Ltd
Towler Bros (Patents) Ltd
Walker Ltd, C. & W.
Western Detail Mfrs Ltd

VALVES (BY OPERATION)—THERMOSTATIC
★ Circle *No 536* on reply card
General Electric Co Ltd, The
Gordon & Co Ltd, James
Newman, Hender & Co Ltd
Perfection Parts Ltd
Ryder & Co (Manchester) Ltd, Thomas
Teddington Industrial Equipment Ltd
Thermocontrol Installations Co Ltd

VALVES (BY OPERATION)—VACUUM
★ Circle *No 537* on reply card
Appleby & Ireland Ltd
Babcock & Wilcox Ltd
Bell Precision Engineering Co Ltd
B.E.N. Patents Ltd
Blundell & Crompton Ltd
Crosby Valve & Engineering Co Ltd
Electro-Hydraulics Ltd
Gordon & Co Ltd, James
Inness & Co (Darlington) Ltd
IV Pressure Controllers Ltd
Leybold Vacuum Sales Ltd
Martonair Ltd
Metropolitan-Vickers Electrical Co Ltd
Newman, Hender & Co Ltd
NGN Electrical Ltd
Pulsometer Engineering Co Ltd, The
Ryder & Co (Manchester) Ltd, Thomas
Saunders Valve Co Ltd
Vacuum Industrial Applications Ltd
Warren Morrison Ltd
Western Detail Mfrs Ltd

VALVES (BY PURPOSE)—AIR
★ Circle *No 538* on reply card
Aerospray Associated Ltd
Alexander Controls Ltd
Appleby & Ireland Ltd
Babcock & Wilcox Ltd
Bailey & Co Ltd, Sir W. H.
Baldwin Instrument Co Ltd
Ben Patents Ltd
British Ermeto Corporation Ltd
British Steam Specialties Ltd
Chatwood-Milner Ltd

VALVES (BY PURPOSE)—AIR—*continued*
Dewrance & Co Ltd
Glenfield & Kennedy Ltd
Globe Pneumatic Eng Co Ltd
Gordon & Co Ltd, James
Harland Engineering Co Ltd
High Pressure Components Ltd
Hindle & Sons Ltd, Joshua
Hopkinsons Ltd
Inness & Co (Darlington) Ltd
IV Pressure Controllers Ltd
Kirk & Co (Tubes) Ltd
Lang Pneumatic Ltd
Magnetic Valve Co Ltd, The
Martonair Ltd
Metro-Flex Atomic Engineering Ltd
Newman, Hender & Co Ltd
Norgren Ltd, C. A.
Perfection Parts Ltd
Ryder & Co (Manchester) Ltd, Thomas
Saunders Valve Co Ltd
SPE Co Ltd (non-return)
Spembly Ltd
Vacuum Industrial Applications Ltd
Western Detail Mfrs Ltd

VALVES (BY PURPOSE)—CHEMICALS (INCLUDING HEAVY WATER)
★ Circle *No 539* on reply card
Alexander Controls Ltd
Appleby & Ireland Ltd
Appleton & Howard Ltd
Bailey & Co Ltd, Sir W. H.
British Ermeto Corporation Ltd
Electro-Hydraulics Ltd
Extrudex Ltd
Glenfield & Kennedy Ltd
Gordon & Co Ltd, James
Harland Engineering Co Ltd
Hathernware Ltd
Hindle & Sons Ltd, Joshua
Inness & Co (Darlington) Ltd
IV Pressure Controllers Ltd
Kestner Evaporator & Engineering Co Ltd
Kirk & Co (Tubes) Ltd
Langley Alloys Ltd
Millspaugh Ltd
Newman, Hender & Co Ltd
Palatine Tool & Engineering Co (Surbiton) Ltd
Perfection Parts Ltd
Plessey Nucleonics Ltd
QVF Ltd
Ryder & Co (Manchester) Ltd, Thomas
Saunders Valve Co Ltd
Talbot Stead Tube Co Ltd
TI Nuclear Engineering Ltd
Western Detail Mfrs Ltd

VALVES (BY PURPOSE)—GASES
★ Circle *No 540* on reply card
Appleby & Ireland Ltd
Babcock & Wilcox Ltd
Bailey & Co Ltd, Sir W. H.
Baldwin Instrument Co Ltd
Blakeborough & Sons Ltd, J.
Blundell & Crompton Ltd
British Ermeto Corporation Ltd
Chatwood-Milner Ltd
Callow (Engineers) Ltd, F. E.
Electro-Hydraulics Ltd
Flight Refuelling Ltd
Glenfield & Kennedy Ltd
Gordon & Co Ltd, James
Harland Engineering Co Ltd
High Pressure Components Ltd
Hindle & Sons Ltd, Joshua
Hopkinsons Ltd
Inness & Co (Darlington) Ltd
IV Pressure Controllers Ltd
Kirk & Co (Tubes) Ltd
Klinger Ltd, Richard
Langley Alloys Ltd
Magnetic Valve Co Ltd, The
Metro-Flex Atomic Engineering Ltd
Newman, Hender & Co Ltd
Palatine Tool & Engineering Co (Surbiton) Ltd
Perfection Parts Ltd
Plessey Nucleonics Ltd
Ryder & Co (Manchester) Ltd, Thomas
Saunders Valve Co Ltd
Walter Ltd, C. & W.

VALVES (BY PURPOSE)—HYDRAULIC CONTROL
★ Circle *No 541* on reply card
Alexander Controls Ltd
Appleby & Ireland Ltd
Bailey & Co Ltd, Sir W. H.
Baldwin Instrument Co Ltd
British Ermeto Corporation Ltd
British Steam Specialties Ltd
Chamberlain Industries Ltd
Cravens Ltd
Electro-Hydraulics Ltd
Ellison Ltd, George
Glenfield & Kennedy Ltd
Gordon & Co Ltd, James
Harland Engineering Co Ltd
High Pressure Components Ltd
Hindle & Sons Ltd, Joshua
Integral Ltd
IV Pressure Controllers Ltd
Keelavite Hydraulics Ltd
Kirk & Co (Tubes) Ltd
Madan & Co Ltd, Charles S.
Magnetic Valve Co Ltd, The
Martonair Ltd
Newman, Hender & Co Ltd
Perfection Parts Ltd
Ryder & Co (Manchester) Ltd, Thomas
Saunders Valve Co Ltd
Short Bros & Harland Ltd
Telehoist Ltd
Thermocontrol Installations Co Ltd
Towler Bros (Patents) Ltd
Western Detail Mfrs Ltd

VALVES (BY PURPOSE)—LIQUID METALS
★ Circle *No 542* on reply card
Appleby & Ireland Ltd
APV Co Ltd, The

VALVES (BY PURPOSE)—LIQUID METALS—*continued*
Armstrong Siddeley Motors Ltd
British Ermeto Corporation Ltd
Glenfield & Kennedy Ltd
Harland Engineering Co Ltd
Newman, Hender & Co Ltd
Palatine Tool & Engineering Co (Surbiton) Ltd
Ryder & Co (Manchester) Ltd, Thomas
Saunders Valve Co Ltd
Western Detail Mfrs Ltd

VALVES (BY PURPOSE)—PNEUMATIC CONTROL
★ Circle *No 543* on reply card
Alexander Controls Ltd
Appleby & Ireland Ltd
Babcock & Wilcox Ltd
Bailey & Co Ltd, Sir W. H.
Baldwin Instrument Co Ltd
Ben Patents Ltd
British Ermeto Corporation Ltd
Crosby Valve & Engineering Co Ltd
Electro-Hydraulics Ltd
Ellison Ltd, George
Glenfield & Kennedy Ltd
Globe Pneumatic Eng Co Ltd
Gordon & Co Ltd, James
Harland Engineering Co Ltd
High Pressure Components Ltd
Hindle & Sons Ltd, Joshua
Inness & Co (Darlington) Ltd
IV Pressure Controllers Ltd
Kent Ltd, George
Lang Pneumatic Ltd
Leybold Vacuum Sales Ltd
Magnetic Valve Co Ltd, The
Martonair Ltd
Newman, Hender & Co Ltd
Norgren Ltd, C. A.
Perfection Parts Ltd
Ryder & Co (Manchester) Ltd, Thomas
Saunders Valve Co Ltd
Teddington Industrial Equipment Ltd
Thermocontrol Installations Co Ltd
United States Metallic Packing Co Ltd

VALVES (BY PURPOSE)—STEAM
★ Circle *No 544* on reply card
Alexander Controls Ltd
Appleby & Ireland Ltd
Babcock & Wilcox Ltd
Bailey & Co Ltd, Sir W. H.
Blakeborough & Sons Ltd, J.
British Ermeto Corporation Ltd
British Steam Specialties Ltd
Crosby Valve & Engineering Co Ltd
Cockburns Ltd
Dewrance & Co Ltd
Gordon & Co Ltd, James
Harland Engineering Co Ltd
High Pressure Components Ltd
Hindle & Sons Ltd, Joshua
Hopkinsons Ltd
Inness & Co (Darlington) Ltd
IV Pressure Controllers Ltd
Kirk & Co (Tubes) Ltd
Klinger Ltd, Richard
Langley Alloys Ltd
Magnetic Valve Co Ltd, The
Newman, Hender & Co Ltd
Perfection Parts Ltd
Ryder & Co (Manchester) Ltd, Thomas
Shaw-Petrie Ltd
Stewarts & Lloyds Ltd
Thermocontrol Installations Co Ltd
United States Metallic Packing Co Ltd
Weir Valves Ltd

VALVES (BY PURPOSE)—VACUUM
★ Circle *No 545* on reply card
Alexander Controls Ltd
Appleby & Ireland Ltd
Babcock & Wilcox Ltd
Baldwin Instrument Co Ltd
Ben Patents Ltd
Blundell & Crompton Ltd
British Ermeto Corporation Ltd
British Steam Specialties Ltd
Edwards High Vacuum Ltd
Gordon & Co Ltd, James
Hindle & Sons Ltd, Joshua
Inness & Co (Darlington) Ltd
IV Pressure Controllers Ltd
Leybold Vacuum Sales Ltd
Magnetic Valve Co Ltd, The
Martonair Ltd
Metropolitan-Vickers Electrical Co Ltd
Newman, Hender & Co Ltd
NGN Electrical Ltd
Palatine Tool & Engineering Co (Surbiton) Ltd
Perfection Parts Ltd
Pulsometer Engineering Co Ltd, The
Ryder & Co (Manchester) Ltd, Thomas
Saunders Valve Co Ltd
Stainless Steel Vessels (London) Ltd
Sykes Ltd, Henry
Vacuum Industrial Applications Ltd
Western Detail Mfrs Ltd

VALVES (BY PURPOSE)—WATER
★ Circle *No 546* on reply card
Alexander Controls Ltd
Appleby & Ireland Ltd
Bailey & Co Ltd, Sir W. H.
Baldwin Instrument Co Ltd
Blakeborough & Sons Ltd, J.
British Ermeto Corporation Ltd
British Steam Specialties Ltd
Cockburns Ltd
Dewrance Ltd
Electro-Hydraulics Ltd
Elliott Bros (London) Ltd
Extrudex Ltd
Glenfield & Kennedy Ltd
Gordon & Co Ltd, James
Ham, Baker & Co Ltd
Harland Engineering Co Ltd
High Pressure Components Ltd
Hindle & Sons Ltd, Joshua
Hopkins & Co Ltd, F.
Hopkinsons Ltd

VALVES (BY PURPOSE)—WATER—*continued*
Horseley Bridge & Thomas Piggott Ltd
Inness & Co (Darlington) Ltd
IV Pressure Controllers Ltd
Jones & Stevens Ltd
Kirk & Co (Tubes) Ltd
Klinger Ltd, Richard
Langley Alloys Ltd
Magnetic Valve Co Ltd, The
Millspaugh Ltd
Newman, Hender & Co Ltd
Perfection Parts Ltd
Ryder & Co (Manchester) Ltd, Thomas
Saunders Valve Co Ltd
Stewarts & Lloyds Ltd
United States Metallic Packing Co Ltd
Weir Valves Ltd

VENTILATORS—NATURAL DRAUGHT
★ Circle *No 547* on reply card
Andrew Machine Construction Co Ltd, The
Birmingham & Blackburn Construction Co Ltd
Colt Ventilation Ltd
Fenton, Byrn & Co Ltd
Hargreaves & Sons Ltd, Henry
Harvey & Co (London) Ltd, G. A.
Hills (West Bromwich) Ltd
Mancuna Engineering Ltd
Ryder & Co (Manchester) Ltd, Thomas
Southborough (Weybridge) Ltd
Supervents Ltd
Tupholme & Co Ltd, George E.
Walker & Co (Halifax) Ltd, P. M.

VENTILATORS—MECHANICAL EXTRACT
★ Circle *No 548* on reply card
Andrew Machine Construction Co Ltd, The
Biddle Ltd, F. H.
Birmingham & Blackburn Construction Co Ltd
Carrier Engineering Co Ltd
Colt Ventilation Ltd
Davidson & Co Ltd
Extrudex Ltd
Fenton, Byrn & Co Ltd
General Electric Co Ltd, The
Hargreaves & Sons Ltd, Henry
Harvey & Co (London) Ltd, G. A.
Hills (West Bromwich) Ltd
Keith Blackman Ltd
Mancuna Engineering Ltd
Ozonair Engineering Co Ltd
Ryder & Co (Manchester) Ltd, Thomas
Standard & Pochin Bros Ltd, The
Sturtevant Engineering Co Ltd
Supervents Ltd
Tupholme & Co Ltd, George E.
Vent-Axia Ltd
Walker & Co (Halifax) Ltd, P. M.
Woods of Colchester Ltd
Wykeham & Co Ltd, W.

VESSELS—CHEMICAL REACTION
★ Circle *No 549* on reply card
Adamson & Co Ltd, Daniel
Apex Construction Ltd
APV Co Ltd, The
Babcock & Wilcox Ltd
Balfour & Co Ltd, Henry
Butterfield Ltd, W. P.
Capper & Co Ltd, William H.
Chesterfield Tube Co Ltd, The
Constructors John Brown Ltd
Davey, Paxman & Co Ltd
English Steel Corporation Ltd
Extrudex Ltd
Foster, Yates & Thom Ltd
Fraser & Co Ltd, W. J.
Freeman, Taylor Machines Ltd
Hathernware Ltd
Head Wrightson & Co Ltd (Nuclear Power Div)
Heat Exchangers Ltd
Heat Transfer Ltd
Horseley Bridge & Thomas Piggott Ltd
Jenkins & Co Ltd, Robert
Kestner Evaporator & Engineering Co Ltd
Mason (Chemical Engineers) Ltd, G. Samuel
Metal Propellers Ltd
Motherwell Bridge & Engineering Co Ltd, The
Munro & Miller Ltd
Newton, Chambers & Co Ltd
Nuclear Engineering Ltd
QVF Ltd
Ruston & Hornsby Ltd
Ryder & Co (Manchester) Ltd, Thomas
Simon-Carves Ltd
Southborough (Weybridge) Ltd
Stainless Steel Vessels (London) Ltd
Thompson (Dudley) Ltd, John
Thompson (Wolverhampton) Ltd, John
Walker Ltd, C. & W.
Western Detail Mfrs Ltd
Widnes Foundry & Engineering Co Ltd

VESSELS—LEAD LINED
★ Circle *No 550* on reply card
Birmingham & Blackburn Contruction Co Ltd
Birwelco Ltd
Butterfield Ltd, W. P.
Grazebrook Ltd, M. & W.
Head Wrightson & Co Ltd (Nuclear Power Div)
Heat Exchangers Ltd
Jenkins & Co Ltd, Robert
Kestner Evaporator & Engineering Co Ltd
Mason (Chemical Engineers) Ltd, Samuel G.
Ryder & Co (Manchester) Ltd, Thomas
Southborough (Weybridge) Ltd
Walker Ltd, C. & W.
Western Detail Mfrs Ltd

VESSELS—PRESSURE
★ Circle *No 551* on reply card
Aerospray Associated Ltd
Aerox Ltd
Aiton & Co Ltd
Allen & Sons (Tipton) Ltd, W. G.
APV Co Ltd, The
Ashmore, Benson, Pease & Co
Ayling Nuclear Equipment Co
Babcock & Wilcox Ltd
Balfour & Co Ltd, Henry
Bawn & Co Ltd, W. B.
Beardmore & Co Ltd, William

VESSELS—PRESSURE—*continued*
Bennett Sons & Shears Ltd
Birmingham & Blackburn Construction Co Ltd
Birwelco Ltd
Blundell & Crompton Ltd
Braby & Co Ltd, Fredr.
Bristol Aircraft Ltd
Brown Land Boilers Ltd, John
Burnett & Lewis Ltd
Butterfield Ltd, W. P.
Capper & Co Ltd, William H.
Chatwood-Milner Ltd
Chesterfield Tube Co Ltd, The
Clarke, Chapman & Co Ltd
Cravens Ltd
Darham Industries (London) Ltd
Davey, Paxman & Co Ltd
English Steel Corp Ltd
Foster Wheeler Ltd
Foster Yates & Thom Ltd
Fraser & Co Ltd, W. J.
Freeman, Taylor Machines Ltd
General Electric Co Ltd, The
Grazebrook Ltd, M. & W.
Hargreaves & Sons Ltd, Henry
Harris (Birmingham) Ltd, F. & R. M.
Harvey & Co (London) Ltd, G. A.
Head Wrightson & Co Ltd (Nuclear Power Div)
Head Wrightson Processes Ltd
Heat Exchangers Ltd
Heat Transfer Ltd
Hobson Ltd, H. M.
Horseley Bridge & Thomas Piggott Ltd
International Combustion Ltd
IV Pressure Controllers Ltd
Jenkins & Co Ltd, Robert
Marshall & Co (Motherwell) Ltd, John
Marston Excelsior Ltd (Aluminium Only)
Millspaugh Ltd
Moore & Co Ltd, W. & E.
Morrison, Marshall & Hill Ltd
Motherwell Bridge & Engineering Co Ltd, The
Munro & Miller Ltd
Newton, Chambers & Co Ltd
Nuclear Engineering Ltd
Nuclear Power Plant Co Ltd, The
Pearson & Sons Ltd, T. B.
Robertson & Ferguson Ltd
Robey & Co Ltd
Ruston & Hornsby Ltd
Ryder & Co (Manchester) Ltd, Thomas
Rye-Arc Ltd
Simmons & Hawker Ltd
Simon-Carves Ltd
Southborough (Weybridge) Ltd
Stainless Steel Vessels (London) Ltd
Steels Engineering Installations Ltd
Thompson (Dudley) Ltd, John
Thompson (Wolverhampton) Ltd, John
Unit Superheater & Pipe Co Ltd, The
Walker Ltd, C. & W.
Ward Ltd, Thos W.
Watson & Co Ltd, Robert
Western Detail Mfrs Ltd
Whessoe Ltd
Widnes Foundry & Engineering Co Ltd
Williams & James (Engineers) Ltd
Wilmot Breeden Ltd
Windshields of Worcester Ltd
Yarrow & Co Ltd

VESSELS—STAINLESS STEEL
★ Circle *No 552* on reply card
Apex Construction Ltd
APV Co Ltd, The
Birmingham & Blackburn Construction Co Ltd
Birwelco Ltd
Butterfield Ltd, W. P.
Cravens Ltd
Electro-Hydraulics Ltd
Fraser & Co Ltd, W. J.
Freeman, Taylor Machines Ltd
Grazebrook Ltd, M. & W.
Head Wrightson & Co Ltd (Nuclear Power Div)
Heat Exchangers Ltd
Heat Transfer Ltd
Jenkins & Co Ltd, Robert
Mason (Chemical Engineers) Ltd, G. Samuel
Metaducts Ltd
Moore & Co Ltd, W. & E.
Motherwell Bridge & Engineering Co Ltd, The
Munro & Miller Ltd
Newton, Chambers Ltd
Palatine Tool & Engineering Co (Surbiton) Ltd
Ruston & Hornsby Ltd
Ryder & Co (Manchester) Ltd, Thomas
Southborough (Weybridge) Ltd
Stainless Steel Vessels (London) Ltd
Thompson (Dudley) Ltd, John
Thompson (Wolverhampton) Ltd, John
Walker Ltd, C. & W.
Ward Ltd, Thos W.
Watson & Co Ltd, Robert
Western Detail Mfrs Ltd
Wilmot Breeden Ltd

WEIGHING MACHINES
★ Circle *No 553* on reply card
Davy & United Engineering Co Ltd
Denison & Son Ltd, Samuel
Elliott Bros (London) Ltd
Magnetic Equipment Co Ltd, The
Research & Control Instruments Ltd
Simon & Sons Ltd, Richard

WELDING CONTRACTORS
★ Circle *No 554* on reply card
Anglo Swedish Electric Welding Co Ltd
Ashmore, Benson, Pease & Co
Barimar Ltd
Capper & Co Ltd, William H.
Chatwood-Milner Ltd
Deloro Stellite Ltd
Fairey Aviation Co Ltd, The
Ferguson & Robertson Ltd
Foster Wheeler Ltd
General Steel Group
Hall & Co Ltd, Matthew
Horseley Bridge & Thomas Piggott Ltd
Merrill Pumps Ltd
Millspaugh Ltd

WELDING CONTRACTORS—*contractors*
Moore & Co Ltd, W. & E.
Motherwell Bridge & Engineering Co Ltd
Murex Welding Processes Ltd
Napier & Son Ltd, D.
Nuclear Engineering Ltd
Rockweld Ltd
Ryder & Co (Manchester) Ltd, Thos.
Rye-Arc Ltd
Shaw-Petrie Ltd
Simmons & Hawker Ltd
Stokes, Taylor & Shaw Ltd
Suffolk Iron Foundry (1920) Ltd
Ward Ltd, Thos. W.
Welding Supervision Ltd
Yorkshire Engineering & Welding Co Ltd

WELDING BLOWPIPES
★ Circle *No 556* on reply card
Acetylene Generator & Tool Co Ltd
Baddeley Engineering Co Ltd, D. S.
British Industrial Gases Ltd
British Oxygen Gases Ltd
Centrajet Ltd
Milne & Co Ltd, C. S.
Oxhycarbon Co Ltd
Pollock & Peel Ltd
Saturn Industrial Gases Ltd

WELDING ELECTRODES
★ Circle *No 557* on reply card
Arc Mfg Co Ltd
Armco Ltd
British Insulated Callender's Cables Ltd
Cooper & Turner
Deloro Stellite Ltd
English Electric Co Ltd, The
Eutectic Welding Alloys Ltd
Fuller Electric Co Ltd
Lincoln Electric Co Ltd
Metropolitan-Vickers Electrical Co Ltd
Milne & Co Ltd, C. S.
Murex Welding Processes Ltd
Quasi-Arc Ltd
Philips Electrical Ltd
Rediweld-Oerlikon Electrodes Ltd
Rockweld Ltd
Sciaky Electric Welding Machines Ltd
Siebe, Gorman & Co Ltd
Welding Supplies Ltd

WELDING ELECTRODE HOLDERS
★ Circle *No 558* on reply card
Arc Mfg Co Ltd
Baddeley Engineering Co Ltd, D. S.
English Electric Co Ltd, The
General Electric Co Ltd, The
Lincoln Electric Co Ltd
Metropolitan-Vickers Electrical Co Ltd
Milne & Co Ltd, C. S.
Murex Welding Processes Ltd
Quasi-Arc Ltd
Philips Electrical Ltd
Rediweld-Oerlikon Electrodes Ltd
Rockweld Ltd
Ross & Partners Ltd, Donald
Siebe, Gorman & Co Ltd
Welding Supplies Ltd
Young & Co Ltd, A. S.

WELDING FLUXES
★ Circle *No 559* on reply card
Armco Ltd
Baddeley Engineering Co Ltd, D. S.
British Industrial Gases Ltd
British Oxygen Gases Ltd
Eutectic Welding Alloys Ltd
Fuller Electric Ltd
Lincoln Electric Co Ltd
Milne & Co Ltd, C. S.
Sheffield Smelting Co Ltd, The
Suffolk Iron Foundry (1920) Ltd
Welding Supplies Ltd
Young & Co Ltd, A. S.

WELDING GASES
★ Circle *No 560* on reply card
British Industrial Gases Ltd
British Oxygen Gases Ltd (Oxygen, Acetylene, Nitrogen, Argon, Propane, Hydrogen, Coal Gas Compressed Air)
Imperial Chemical Industries Ltd (Argon)
Saturn Industrial Gases Ltd (Propane, Argon)

WELDING GAS REGULATORS
★ Circle *No 561* on reply card
Acetylene Generator & Tool Co Ltd
Baddeley Engineering Co Ltd, D. S.
British Industrial Gases Ltd
British Oxygen Gases Ltd
Milne & Co Ltd, C. S.
Oxhycarbon Co Ltd
Saturn Industrial Gases Ltd
Siebe, Gorman & Co Ltd
Suffolk Iron Foundry (1920) Ltd
Young & Co Ltd, A. S.

WELDING MACHINES—PROJECTION
★ Circle *No 562* on reply card
Electro Mechan-Heat Ltd
Fuller Electric Ltd
Hirst Electronic Ltd
Meritus (Barnet) Ltd
Metro-Cutanit Ltd
Metropolitan-Vickers Electrical Co Ltd
Philips Electrical Ltd
Sciaky Electric Welding Machines Ltd
Soag Machine Tools Ltd

WELDING MACHINES—SEAM
★ Circle *No 563* on reply card
Bode & Son Ltd, F.
British Federal Welder & Mc. Co Ltd
Electro Mechan-Heat Ltd
Fuller Electric Ltd
Igranic Electric Co Ltd
Lancashire Dynamo Electronic Products Ltd
Meritus (Barnet) Ltd
Metro-Cutanit Ltd
Metropolitan-Vickers Electrical Co Ltd
Milne & Co Ltd, C. S.
Philips Electrical Ltd

WELDING MACHINES—SEAM—*continued*
Sciaky Electric Welding Machines Ltd
Soag Machine Tools Ltd
Welding Supplies Ltd
Young & Co Ltd, A. S.

WELDING MACHINES—SHIELDED ARC
★ Circle *No 564* on reply card
Arc Mfg Co Ltd
British Oxygen Gases Ltd
Metropolitan-Vickers Electrical Co Ltd
Philips Electrical Ltd
Quasi-Arc Ltd
Rockweld Ltd
Saturn Industrial Gases Ltd

WELDING MACHINES—SPOT
★ Circle *No 565* on reply card
Baddeley Engineering Co Ltd, D. S.
British Federal Welder & Mc. Co Ltd
British Oxygen Gases Ltd
Electro Mechan-Heat Ltd
Fuller Electric Ltd
Hirst Electronic Ltd
Igranic Electric Co Ltd
Lancashire Dynamo Electronic Products Ltd
Meritus (Barnet) Ltd
Metropolitan-Vickers Electrical Co Ltd
Milne & Co Ltd, C. S.
Philips Electrical Ltd
Soag Machine Tools Ltd
Sciaky Electric Welding Machines Ltd
Young & Co Ltd, A. S.

WELDING MACHINES—STUD
★ Circle *No 566* on reply card
Crompton Parkinson Ltd
Electro Mechan-Heat Ltd
Fuller Electric Ltd
Meritus (Barnet) Ltd
Philips Electrical Ltd
Sciaky Electric Welding Machines Ltd

WELDING MACHINES—SUBMERGED ARC
★ Circle *No 567* on reply card
Lincoln Electric Co Ltd
Metropolitan-Vickers Electrical Co Ltd
Philips Electrical Ltd
Quasi-Arc Ltd
Rediweld-Oerlikon Electrodes Ltd
Rockweld Ltd
Welding Supplies Ltd

WELDING MOTOR GENERATOR SETS
★ Circle *No 568* on reply card
Armco Ltd
Fuller Electric Co Ltd
General Electric Co Ltd, The
Lincoln Electric Co Ltd
Metropolitan-Vickers Electrical Co Ltd
Murex Welding Processes Ltd
Newman Industries Ltd
Petbow Ltd
Quasi-Arc Ltd
Rediweld-Oerlikon Electrodes Ltd
Welding Supplies Ltd
Young & Co Ltd, A. S.

WELDING POSITIONERS
★ Circle *No 569* on reply card
Bode & Son Ltd, F.
Courtburn Positioners Ltd
Metropolitan-Vickers Electrical Co Ltd
Neill & Co (Sheffield) Ltd, James
Quasi-Arc Ltd
Ross & Partners Ltd, Donald
Yates Plant Ltd

WELDING PREHEATING EQUIPMENT
★ Circle *No 570* on reply card
Acetylene Generator & Tool Co Ltd
Baddeley Engineering Co Ltd, D. S.
British Industrial Gases Ltd
British Oxygen Gases Ltd
Fuller Electric Ltd
General Electric Co Ltd, The
Metropolitan-Vickers Electrical Co Ltd
Oxhycarbon Co Ltd
Quasi-Arc Ltd
Saturn Industrial Gases Ltd

WELDING RECTIFIERS
★ Circle *No 571* on reply card
Arc Mfg Co Ltd
Baddeley Engineering Co Ltd, D. S.
British Oxygen Gases Ltd
Crompton Parkinson Ltd
English Electric Co Ltd, The
General Electric Co Ltd, The
Hackbridge & Hewittic Electric Co Ltd
Meritus (Barnet) Ltd
Metropolitan-Vickers Electrical Co Ltd
Murex Welding Processes Ltd
Philips Electrical Ltd
Quasi-Arc Ltd

WELDING TRANSFORMERS
★ Circle *No 572* on reply card
Arc Mfg Co Ltd
Baddeley Engineering Co Ltd, D. S.
Balbo Welding Processes Ltd
British Oxygen Gases Ltd
Electro Mechan-Heat Ltd
English Electric Co Ltd, The
Fuller Electric Ltd
General Electric Co Ltd, The
Hirst Electronic Ltd
Hackbridge & Hewittic Electric Co Ltd
Meritus (Barnet) Ltd
Metropolitan-Vickers Electrical Co Ltd
Milne & Co Ltd, C. S.
Murex Welding Processes Ltd
Philips Electrical Ltd
Quasi-Arc Ltd
Rockweld Ltd
Welding Industries Ltd
Welding Supplies Ltd
Young & Co Ltd, A. S.

WIREWORK—PROTECTIVE
★ Circle *No 555* on reply card
Barns & Son Ltd, W.
Braby & Co Ltd, Fredr
Endecotts (Filters) Ltd

Section 2

Instruments and laboratory equipment

ABSORBERS—RADIATION
★ Circle *No 602* on reply card
General Electric Co Ltd, The (heavy alloy)
Isotope Developments Ltd
Labgear Ltd
Mendip (Chemical Engineering) Ltd
Panax Equipment Ltd

ABSORPTIOMETERS
★ Circle *No 603* on reply card
Baird & Tatlock (London) Ltd
Evans Electroselenium Ltd
Gallenkamp & Co Ltd, A.
Hilger & Watts Ltd
Joyce, Loebl & Co Ltd
Lock & Co Ltd, A. M.

ACCELERATORS—PARTICLE
★ Circle *No 604* on reply card
Mullard Ltd
Metropolitan-Vickers Electrical Co Ltd
Research & Control Instruments Ltd

AIR SAMPLING EQUIPMENT
★ Circle *No 605* on reply card
Barcross Ltd
Casella & Co Ltd, C. F.
Fleming Radio (Developments) Ltd
Minerva Detector Co Ltd
Nash & Thompson Ltd
Rotheroe & Mitchell Ltd
Winston Electronics Ltd

ALARMS—FLOW
★ Circle *No 606* on reply card
Accurate Recording Instrument Co, The
Allied Electronics Ltd
Edwards High Vacuum Ltd
Elliott Bros (London) Ltd
Evershed & Vignoles Ltd
Fielden Electronics Ltd
General Electric Co Ltd, The
Gordon & Co Ltd, James
KDG Instruments Ltd
Kent Ltd, George
Lancashire Dynamo Electronic Products Ltd
Liquid Systems Ltd
Lock & Co Ltd, A. M.
Londex Ltd
Negretti & Zambra Ltd
Rotameter Mfg Co Ltd
Standard Telephones & Cables Ltd
Sunvic Controls Ltd
Thermocontrol Installations Co Ltd
Universal Control Equipment Ltd

ALARMS—HIGH FLUX
★ Circle *No 607* on reply card
Ericsson Telephones Ltd
Research & Control Instruments Ltd
Sunvic Controls Ltd

ALARMS—PRESSURE
★ Circle *No 608* on reply card
Accurate Recording Instrument Co, The
Appleby & Ireland Ltd
Edwards High Vacuum Ltd
Elliott Bros (London) Ltd
Evershed & Vignoles Ltd
Fielden Electronics Ltd
General Electric Co Ltd, The
Gordon & Co Ltd, James
Hopkinsons Ltd
Ionic Instruments (London) Ltd
Kent Ltd, George
KGD Instruments Ltd
Lancashire Dynamo Electronic Products Ltd
Lock & Co Ltd, A. M.
Londex Ltd
McKellen Automation Ltd
Negretti & Zambra Ltd
Salford Electrical Instruments Ltd
Sunvic Controls Ltd
Thermocontrol Installations Co Ltd
Universal Control Equipment Ltd

ALARMS—RADIATION
★ Circle *No 609* on reply card
British Thomson-Houston Co Ltd, The
Dowty Nucleonics Ltd
Elliott Bros (London) Ltd
Ericsson Telephones Ltd
General Electric Co Ltd, The
General Radiological Ltd
Isotope Developments Ltd
Labgear Ltd
Panax Equipment Ltd
Plessey Nucleonics Ltd
Research & Control Instruments Ltd
Sunvic Controls Ltd
Thermocontrol Installations Co Ltd

ALARMS—TEMPERATURE
★ Circle *No 610* on reply card
Accurate Recording Instrument Co, The
Allied Electronics Ltd
Appleby & Ireland Ltd
British Thomson-Houston Co Ltd, The
Cambridge Instrument Co Ltd
Electro Methods Ltd

ALARMS—TEMPERATURE—*continued*
Elliott Bros (London) Ltd
Evershed & Vignoles Ltd
Fielden Electronics Ltd
Foster Instrument Co Ltd
General Electric Co Ltd, The
Gordon & Co Ltd, James
Kent Ltd, George
KDG Instruments Ltd
Lancashire Dynamo Electronic Products Ltd
Leland Instruments Ltd
Lock & Co Ltd, A. M.
McKellen Automation Ltd
Negretti & Zambra Ltd
Research & Control Instruments Ltd
Sunvic Controls Ltd
Thermocontrol Installations Co Ltd
Universal Control Equipment Ltd

AMPLIFIERS—d.c.
★ Circle *No 611* on reply card
Airmec Ltd
Allied Electronics Ltd
Armstrong Whitworth Aircraft Ltd, Sir W. G.
Avo Ltd
Bailey Meters & Controls Ltd
B & K Laboratories Ltd
Boulton Paul Aircraft Ltd
British Physical Laboratories
British Thomson-Houston Co Ltd, The
Cawkell Research & Electronics Ltd
Cossor Instruments Ltd
Dowty Nucleonics Ltd
Dynatron Radio Ltd
Ekco Electronics Ltd
Electroflo Ltd
Electro Methods Ltd
Electronic Instruments Ltd
Elliott Bros (London) Ltd
EMI Electronics Ltd
Ericsson Telephones Ltd
Evershed & Vignoles Ltd
Falk & Co Ltd, M.
Fielden Electronics Ltd
Fleming Radio (Developments) Ltd
Foster Instruments Ltd
General Radiological Ltd
Holiday & Hemmerdinger Ltd
Honeywell-Brown Ltd
Hilger & Watts Ltd
Integra, Leeds & Northrup Ltd
Isotope Developments Ltd
Kent Ltd, George
Labgear (Cambridge) Ltd
Lancashire Dynamo Electronic Products Ltd
Livingston Laboratories Ltd
McKellen Automation Ltd
Metropolitan-Vickers Electrical Co Ltd
Nagard Ltd
Nash & Thompson Ltd
Panax Ltd
Plessey Nucleonics Ltd
Pye Ltd
Racal Engineering Ltd
Rank Cintel Ltd
Research & Control Instruments Ltd
Richmond Instrument Co Ltd
Savage & Parsons Ltd
Salford Electrical Instruments Ltd
Sangamo Weston Ltd
Scaley Engineering Co Ltd
Short Bros & Harland Ltd
Solartron Electronic Group Ltd
Southern Instruments Ltd
Sullivan Ltd, H. W.
Sunvic Controls Ltd
Tinsley & Co Ltd, H.
Venner Electronics Ltd

AMPLIFIERS—MAGNETIC
★ Circle *No 612* on reply card
Armstrong Whitworth Aircraft Ltd, Sir W. G.
British Thomson-Houston Co Ltd, The
Electro Methods Ltd
Elliott Bros (London) Ltd
English Electric Co Ltd, The
General Electric Co Ltd, The
Hirst Electronic Ltd
Ketay Ltd
Lancashire Dynamo Electronic Products Ltd
Laurence, Scott & Electromotors Ltd
Livingston Laboratories Ltd
Metropolitan-Vickers Electrical Co Ltd
Pullin & Co Ltd, R. B.
Pye Ltd
Racal Engineering Ltd
Scaley Engineering Co Ltd
Winston Electronics Ltd

AMPLIFIERS—PULSE
★ Circle *No 613* on reply card
Armstrong Whitworth Aircraft Ltd, Sir W. G.
British Physical Laboratories
Cawkell Research & Electronics Ltd
Dynatron Radio Ltd
Falk & Co Ltd, M.
General Radiological Ltd
Glass Developments Ltd
Labgear Ltd
Lancashire Dynamo Electronic Products Ltd
Livingston Laboratories Ltd
Metropolitan-Vickers Electrical Co Ltd
Mullard Ltd
Nagard Ltd
Nuclear Enterprises (GB) Ltd
Panax Equipment Ltd
Plessey Nucleonics Ltd

AMPLIFIERS—WIDE-BAND
★ Circle *No 614* on reply card
Airmec Ltd
Allied Electronics Ltd
Armstrong Whitworth Aircraft Ltd, Sir W. G.
Boulton Paul Aircraft Ltd
British Physical Laboratories
Cawkell Research & Electronics Ltd
EMI Electronics Ltd
Falk & Co Ltd, M.
Fleming Radio (Developments) Ltd
Glass Developments Ltd
Labgear Ltd

AMPLIFIERS—WIDE BAND—*continued*
Lancashire Dynamo Electronic Products Ltd
Leland Instruments Ltd
Livingston Laboratories Ltd
McKellen Automation Ltd
Metropolitan-Vickers Electrical Co Ltd
Nagard Ltd
Nuclear Enterprises (GB) Ltd
Panax Equipment Ltd
Plessey Nucleonics Ltd
Standard Telephones & Cables Ltd

ANALYSERS—COINCIDENCE & ANTI-COINCIDENCE
★ Circle *No 615* on reply card
Dynatron Radio Ltd
Leland Instruments Ltd
Livingston Laboratories Ltd
Sunvic Controls Ltd

ANALYSERS—FREQUENCY
★ Circle *No 616* on reply card
Airmec Ltd
B & K Laboratories Ltd
Cawkell Research & Electronics Ltd
Dawe Instruments Ltd
General Electric Co Ltd, The
Integra, Leeds & Northrup Ltd
Livingston Laboratories Ltd
Lyons Ltd, Claude
Mervyn Instruments Ltd
Muirhead & Co Ltd
Salford Electrical Instruments Ltd
Solartron Electronic Group Ltd
Standard Telephones & Cables Ltd
Wayne Kerr Laboratories Ltd

ANALYSERS—FUNCTION
★ Circle *No 617* on reply card
Livingston Laboratories Ltd
Mervyn Instruments
Solartron Electronic Group Ltd
Southern Instruments (Computer Division)

ANALYSERS—GAS
★ Circle *No 618* on reply card
Baird & Tatlock (London) Ltd
Baker Platinum Div, Engelhard Industries Ltd
Cambridge Instrument Co Ltd
Electronic Instruments Ltd
Elliott Bros (London) Ltd
Glass Developments Ltd
Gordon & Co Ltd, James
Griffin & George Ltd
Infra-Red Development Co Ltd, The
Integra, Leeds & Northrup Ltd
Kelvin & Hughes (Industrial) Ltd
Kent Ltd, George
Leybold Vacuum Sales Ltd
Mervyn Instruments
Metropolitan-Vickers Electrical Co Ltd
Shandon Scientific Co Ltd
Towers & Co Ltd, J. W.

ANALYSERS—HEAVY WATER
★ Circle *No 619* on reply card
Mervyn Instruments

ANALYSERS—PARTICLE SIZE
★ Circle *No 620* on reply card
Gallenkamp & Co Ltd, A.
Griffin & George Ltd
Mullard Ltd
Sharples Centrifuges Ltd

ANALYSERS—PULSE AMPLITUDE (SINGLE CHANNEL)
★ Circle *No 621* on reply card
Chatwood-Milner Ltd
Dynatron Radio Ltd
Ekco Electronics Ltd
Falk & Co Ltd, M.
Fleming Radio (Developments) Ltd
Isotope Developments Ltd
Leland Instruments Ltd
Lock & Co Ltd, A. M.
Mullard Ltd
Nuclear Enterprises (GB) Ltd
Research & Control Instruments Ltd

ANALYSERS—PULSE AMPLITUDE (MULTI CHANNEL)
★ Circle *No 622* on reply card
Chatwood-Milner Ltd
Dynatron Radio Ltd
Ekco Electronics Ltd
Falk & Co Ltd, M.
Fleming Radio (Developments) Ltd
Isotope Developments Ltd
Leland Instruments Ltd
Marshall's Flying School Ltd
Mullard Ltd
Research & Control Instruments Ltd
Solartron Electronic Group Ltd
Southern Instruments, Computer Division
Sunvic Controls Ltd

ANALYSERS—TIME (TIME SORTERS)
★ Circle *No 623* on reply card
Cawkell Research & Electronics Ltd
Falk & Co Ltd, M.
Leland Instruments Ltd
Rank Cintel Ltd

ANALYSERS—URANIUM
★ Circle *No 624* on reply card
Mervyn Instruments

ANNUNCIATORS
★ Circle *No 625* on reply card
Chamberlain & Hookham Ltd
Standard Telephones & Cables Ltd
Sunvic Controls Ltd

ANTI-VIBRATION MOUNTINGS
★ Circle *No 626* on reply card
B. & K. Laboratories Ltd
BTR Industries Ltd
Fenner & Co Ltd, J. H.
Griffin & George Ltd
Metalastik Ltd
Precision Rubbers Ltd
Silentbloc Ltd

ANTI-VIBRATION MOUNTINGS—*continued*
Trist & Co Ltd, Ronald
Walker & Co Ltd, James

ASSAY INSTRUMENTS
★ Circle *No 627* on reply card
Allied Electronics Ltd
Casella & Co Ltd, C. F.
Falk & Co Ltd, M.
Ekco Electronics Ltd
Ericsson Telephones Ltd
Isotope Developments Ltd
Labgear Ltd
Mervyn Instruments
Panax Equipment Ltd
Research & Control Instruments Ltd
Southern Instruments (Computer Division)

AUTOCLAVES—LABORATORY
★ Circle *No 628* on reply card
Apex Construction Ltd
Baird & Tatlock (London) Ltd
Blundell & Crompton Ltd
Chatwood-Milner Ltd
Cuthbert Ltd, Ralph
English Electric Co Ltd, The
Gallenkamp & Co Ltd, A.
Griffin & George Ltd
Hadfields Ltd
Harris (Birmingham) Ltd, F. & R. M.
Hospital & Laboratory Supplies Ltd
Isotope Developments Ltd
Morrison, Marshall & Hill Ltd
Nuclear Engineering Ltd
Scientific Furnishings Ltd
Shandon Scientific Co Ltd
Stabilag Co Ltd, The
Stainless Steel Vessels (London) Ltd
Towers & Co Ltd, J. W.
Western Detail Mfrs Ltd
Wilson & Partners Ltd, A. C.

BADGES—FILM
★ Circle *No 629* on reply card
Caxton Name Plate Mfg Co Ltd
Ilford Ltd
Solartron Electronic Group Ltd

BELLOWS—METAL
★ Circle *No 630* on reply card
Appleby & Ireland Ltd
Filton Ltd
Leybold Vacuum Sales Ltd
Palatine Tool & Engineering Co (Surbiton) Ltd
Power Flexible Tubing Co Ltd, The
Teddington Aircraft Controls Ltd
Teddington Industrial Equipment Ltd
TI Nuclear Engineering Ltd

CABINETS—PRESSURIZED ASSEMBLY
★ Circle *No 631* on reply card
Armstrong Whitworth Aircraft Ltd, Sir W. G.
BMB (Sales) Ltd
Falk & Co Ltd, M.
Hutcheon Duthie & Co Ltd, R.
Marine & Industrial Plastics Ltd
QVF Ltd
Ryder & Co (Manchester) Ltd, Thomas
South London Electrical Equipment Co Ltd
Southborough (Weybridge) Ltd
Western Detail Mfrs Ltd

CAMERAS—CATHODE RAY OSCILLOGRAPH
★ Circle *No 632* on reply card
Airmec Ltd
Allied Electronics Ltd
Armstrong Whitworth Aircraft Ltd, Sir W. G.
Avimo Ltd
Cossor Instruments Ltd
Leland Instruments Ltd
Livingston Laboratories Ltd
Lock & Co Ltd, A. M.
Mullard Ltd
Nagard Ltd
Rank Cintel Ltd
Savage & Parsons Ltd
Short Bros & Harland Ltd
Southern Instruments

CAMERAS—CINE
★ Circle *No 633* on reply card
Kodak Ltd
Leland Instruments Ltd
Vinten Ltd
Weyers Bros Ltd

CAMERAS—ELECTRON DIFFRACTION
★ Circle *No 634* on reply card
Edwards High Vacuum Ltd
Stonebridge Electrical Co Ltd

CAMERAS—HIGH SPEED
★ Circle *No 635* on reply card
Avimo Ltd
General Radiological Ltd
Kodak Ltd
Leland Instruments Ltd
Livingston Laboratories Ltd
Nash & Thompson Ltd
Savage & Parsons Ltd
Vinten Ltd
Weyers Bros Ltd
Winston Electronics Ltd

CAMERAS—INDUSTRIAL
★ Circle *No 636* on reply card
Avimo Ltd
Livingston Laboratories Ltd
Mason & Sons Ltd, E. N.
Ross Ensign Ltd
Savage & Parsons Ltd

CAMERAS—SPECTROSCOPIC
★ Circle *No 637* on reply card
Hilger & Watts Ltd
Leland Instruments Ltd
Pye Ltd

CAMERAS—X-RAY DIFFRACTION
★ Circle *No 638* on reply card
General Radiological Ltd
Hilger & Watts Ltd
Philips Electrical Ltd
Pye, Ltd
Solus-Schall Ltd

CASES—INSTRUMENT
★ Circle *No 639* on reply card
Appleby & Ireland Ltd
Armstrong Whitworth Aircraft Ltd, Sir W. G. (flame and explosion arresting)
Avimo Ltd
Brown & Co Ltd, E. G.
Dynatron Radio Ltd
Ericsson Telephones Ltd
Imhofs Ltd
Ionic Instruments (London) Ltd
Labgear Ltd
Leland Instruments Ltd
McKellen Automation Ltd
Panax Equipment Ltd
Permali Ltd
Rank Cintel Ltd
Southborough (Weybridge) Ltd
Winston Electronics Ltd

CATHODE FOLLOWER UNITS
★ Circle *No 640* on reply card
Cawkell Research & Electronics Ltd
Dynatron Radio Ltd
Isotope Developments Ltd
Labgear Ltd
Lancashire Dynamo Electronic Products Ltd
Livingston Laboratories Ltd
Racal Engineering Ltd

CENTRIFUGES—LABORATORY
★ Circle *No 641* on reply card
Appleby & Ireland Ltd
Baird & Tatlock (London) Ltd
Bryans Aeroquipment Ltd
Cuthbert Ltd, Ralph
Gallenkamp & Co Ltd, A.
Griffin & George Ltd
Hospital & Laboratory Supplies Ltd
Laboratory Apparatus & Glass Blowing Co.
Lang London Ltd
Philips Electrical Ltd
Scientific Furnishings Ltd
Shandon Scientific Co Ltd
Sharples Centrifuges Ltd
Vicsons Ltd
Western Detail Mfrs Ltd

CHROMATOGRAPHY APPARATUS
★ Circle *No 642* on reply card
Cuthbert Ltd, Ralph
Gallenkamp & Co Ltd, A.
Griffin & George Ltd
Hanovia Lamps
Isotope Developments Ltd
Joyce, Loebl & Co Ltd
Labgear Ltd
Laboratory Apparatus & Glass Blowing Co
Lock & Co Ltd, A. M.
Metropolitan-Vickers Electrical Co Ltd
Quickfit & Quartz Ltd
QVF Ltd
Research & Control Instruments Ltd
Shandon Scientific Co Ltd
Solartron Electronic Group Ltd
Towers & Co Ltd, J. W

COMPUTER TEST EQUIPMENT
★ Circle *No 643* on reply card
Cawkell Research & Electronics Ltd
Elliott Bros (London) Ltd
Weyers Bros Ltd

COMPUTERS—ANALOGUE
★ Circle *No 644* on reply card
Dowty Nucleonics Ltd
Elliott Bros (London) Ltd
EMI Electronics Ltd
English Electric Co Ltd, The
Evershed & Vignoles Ltd
Fairey Aviation Co Ltd, The
Ferranti Ltd
Lancashire Dynamo Electronic Products Ltd
Leland Instruments Ltd
Metropolitan-Vickers Electrical Co Ltd
Mullard Ltd
Nash & Thompson Ltd
Pye Ltd
Saunders-Roe Ltd
Short Bros & Harland Ltd
Solartron Electronic Group Ltd
Southern Instruments (Computer Division)
Sunvic Controls Ltd
Weyers Bros Ltd

COMPUTERS—DIGITAL
★ Circle *No 645* on reply card
Dowty Nucleonics Ltd
Elliott Bros (London) Ltd
EMI Electronics Ltd
English Electric Co Ltd, The
Ferranti Ltd
Leland Instruments Ltd
Metropolitan-Vickers Electrical Co Ltd
Mullard Ltd
Pye Ltd
Southern Instruments (Computer Division)
Standard Telephones & Cables Ltd
Solartron Electronic Group Ltd
Sunvic Controls Ltd
Weyers Bros Ltd

COMPUTING SERVICES
★ Circle *No 646* on reply card
Elliott Bros (London) Ltd
EMI Electronics Ltd
English Electric Co Ltd, The
Ferranti Ltd
Hawker Siddeley Nuclear Power Co Ltd
Short Bros & Harland Ltd

CONDENSERS—HIGH VOLTAGE
★ Circle *No 647* on reply card
Dubilier Condenser Co (1925) Ltd
Holiday & Hemmerdinger Ltd
Laboratory Apparatus & Glass Blowing Co
Leland Instruments Ltd
Livingston Laboratories Ltd
Philips Electrical Ltd
Plessey Nucleonics Ltd
Standard Telephones & Cables Ltd
Telegraph Condenser Co Ltd, The
Tinsley & Co Ltd, H.

CONNECTORS—WIRE & CABLE
★ Circle *No 648* on reply card
Armstrong Whitworth Aircraft Ltd, Sir W. G.
CWC Equipment Ltd
Electro Methods Ltd
Plessey Nucleonics Ltd
Transradio Ltd

CONTAINERS—ISOTOPE
★ Circle *No 649* on reply card
Andrews, Cuthbert
Chatwood-Milner Ltd
Ekco Electronics Ltd
ERD Engineering Co Ltd
Falk & Co Ltd, M.
General Electric Co Ltd, The
General Radiological Ltd
Grey & Marten Ltd
Hull & Sons Ltd, F.
Isotope Developments Ltd
Johnson, Matthey & Co Ltd
Labgear Ltd
Newton Victor Ltd
Nuclear Engineering Ltd
Pantak Ltd
Rediweld Ltd
Research & Control Instruments Ltd
Savage & Parsons Ltd
Solus-Schall Ltd
Welding Supervision Ltd
Western Detail Mfrs Ltd

CONTAINERS—LINED
★ Circle *No 650* on reply card
Butterfield Ltd, W. P.
Dale Ltd, John
Mills Packard Construction Co Ltd
Rediweld Ltd
Western Detail Mfrs Ltd

CONTROLLERS—FLOW
★ Circle *No 651* on reply card
Accurate Recording Instrument Co, The
Appleby & Ireland Ltd
Crosby Valve & Engineering Co Ltd
Elcontrol Ltd
Elliott Bros (London) Ltd
Evershed & Vignoles Ltd
General Electric Co Ltd, The
Gordon & Co Ltd, James
Honeywell-Brown Ltd
Hopkins & Co Ltd, F.
Hutcheon Duthie & Co Ltd, R.
Ionic Instruments (London) Ltd
IV Pressure Controllers Ltd
Kent Ltd, George
Lock & Co Ltd, A. M.
Negretti & Zambra Ltd
Parkinson & Cowan Ltd
Reavell & Co Ltd
Research & Control Instruments Ltd
Rotameter Mfg Co Ltd
Salford Electrical Instruments Ltd
Sunvic Controls Ltd
Taylor Controls Ltd
Taylor-Short & Mason Ltd
Teddington Industrial Equipment Ltd
Thermocontrol Installations Co Ltd
Ultrasonics Ltd

CONTROLLERS—FURNACE
★ Circle *No 652* on reply card
Appleby & Ireland Ltd
Cambridge Instrument Co Ltd
Elcontrol Ltd
Elliott Bros (London) Ltd
Evershed & Vignoles Ltd
Gordon & Co Ltd, James
Hirst Electronic Ltd
Honeywell-Brown Ltd
Integra, Leeds & Northrup Ltd
Kelvin & Hughes (Industrial) Ltd
Kent Ltd, George
Lancashire Dynamo Electronic Products Ltd
Negretti & Zambra Ltd
Reavell & Co Ltd
Research & Control Instruments Ltd
Taylor-Short & Mason Ltd
Thermocontrol Installations Co Ltd
Western Detail Mfrs Ltd

CONTROLLERS—LEVEL
★ Circle *No 653* on reply card
Airmec Ltd
Appleby & Ireland Ltd
Baldwin Instrument Co Ltd
Crosby Valve & Engineering Co Ltd
Ekco Electronics Ltd
Elliott Bros (London) Ltd
Evershed & Vignoles Ltd
Firth Cleveland Instruments Ltd
Gordon & Co Ltd, James
Ionic Instruments (London) Ltd
KDG Instruments Ltd
Kent Ltd, George
Lancashire Dynamo Electronic Products Ltd
Lock & Co Ltd, A. M.
Londex Ltd
McKellen Automation Ltd
Meynell & Sons Ltd
Negretti & Zambra Ltd
Parkinson & Cowan Ltd
Reavell & Co Ltd
Research & Control Instruments Ltd
Sunvic Controls Ltd
Taylor Controls Ltd
Thermocontrol Installations Co Ltd
Trist & Co Ltd, Ronald
Ultrasonics Ltd

CONTROLLERS—pH
★ Circle *No 654* on reply card
B. & K. Laboratories Ltd
Cambridge Instrument Co Ltd
Cuthbert Ltd, Ralph
Electronic Instruments Ltd
Elliott Bros (London) Ltd
Griffin & George Ltd
Honeywell-Brown Ltd
Integra, Leeds & Northrup Ltd
Ionic Instruments (London) Ltd
Kent Ltd, George
Lock & Co Ltd, A. M.
McKellen Automation Ltd

CONTROLLERS—pH—*continued*
Reavell & Co
Research & Control Instruments Ltd

CONTROLLERS—PRESSURE
★ Circle *No 655* on reply card
Accurate Recording Instrument Co, The
Appleby & Ireland Ltd
Cambridge Instrument Co Ltd
Crosby Valve & Engineering Co Ltd
Edwards High Vacuum Ltd
Elliott Bros (London) Ltd
Eversbed & Vignoles Ltd
General Electric Co Ltd, The
Gordon & Co Ltd, James
Honeywell-Brown Ltd
Hopkin & Co Ltd, F.
Integra, Leeds & Northrup Ltd
Ionic Instruments (London) Ltd
Isenthal & Co Ltd
IV Pressure Controllers Ltd
KDG Instruments Ltd
Kent Ltd, George
McKellen Automation Ltd
Negretti & Zambra Ltd
Parkinson & Cowan Ltd
Reavell & Co Ltd
Research & Control Instruments Ltd
Salford Electrical Instruments Ltd
Savage & Parsons Ltd
Sunvic Controls Ltd
Taylor Controls Ltd
Taylor-Short & Mason Ltd
Teddington Industrial Equipment Ltd
Thermocontrol Installations Co Ltd

CONTROLLERS—PROGRAMME
★ Circle *No 656* on reply card
Allied Electronics Ltd
Appleby & Ireland Ltd
Cawkell Research & Electronics Ltd
Cambridge Instrument Co Ltd
Elliott Bros (London) Ltd
Eversbed & Vignoles Ltd
Foster Instrument Co Ltd
General Electric Co Ltd, The
Gordon & Co Ltd, James
Honeywell-Brown Ltd
Integra, Leeds & Northrup Ltd
Kelvin & Hughes (Industrial) Ltd
Kent Ltd, George
Lancashire Dynamo Electronic Products Ltd
McKellen Automation Ltd
Negretti & Zambra Ltd
Reavell & Co
Research & Control Instruments Ltd
Scaley Engineering Co Ltd
Southern Instruments (Computer Division)
Taylor Controls Ltd
Taylor-Short & Mason Ltd
Thermocontrol Installations Co Ltd
West Instruments Ltd

CONTROLLERS—TEMPERATURE
★ Circle *No 657* on reply card
Accurate Recording Instrument Co, The
Airmec Ltd
Appleby & Ireland Ltd
British Rototherm Co Ltd, The
Cambridge Instrument Co Ltd
CNS Instruments Ltd
Cuthbert Ltd, Ralph
Dowty Nucleonics Ltd
Elcontrol Ltd
Elliott Bros (London) Ltd
Eversbed & Vignoles Ltd
Falk & Co Ltd, M.
Foster Instrument Co Ltd
Gordon & Co Ltd, James
Griffin & George Ltd
Honeywell-Brown Ltd
Integra, Leeds & Northrup Ltd
Isopad Ltd
KDG Instruments Ltd
Kelvin & Hughes (Industrial) Ltd
Kent Ltd, George
Lancashire Dynamo Electronic Products Ltd
Leland Instruments Ltd
Lock & Co Ltd, A. M.
McKellen Automation Ltd
Negretti & Zambra Ltd
Pye Ltd
Reavell & Co Ltd
Research & Control Instruments Ltd
Savage & Parsons Ltd
Sunvic Controls Ltd
Taylor Controls Ltd
Taylor-Short & Mason Ltd
Teddington Industrial Equipment Ltd
Thermocontrol Installations Co Ltd
West Instruments Ltd
Western Detail Mfrs Ltd

CONTROLLERS—VACUUM
★ Circle *No 658* on reply card
Accurate Recording Instrument Co, The
Appleby & Ireland Ltd
Cambridge Instrument Co Ltd
Edwards High Vacuum Ltd
Elliott Bros (London) Ltd
Eversbed & Vignoles Ltd
Gordon & Co Ltd, James
Honeywell-Brown Ltd
Hopkins & Co Ltd, F.
IV Pressure Controllers Ltd
Kent Ltd, George
Lancashire Dynamo Electronic Products Ltd
Leybold Vacuum Sales Ltd
Metropolitan-Vickers Electrical Co Ltd
Negretti & Zambra Ltd
NGN Electrical Ltd
Pulsometer Engineering Co Ltd, The
Reavell & Co Ltd
Salford Electrical Instruments Ltd
Sunvic Controls Ltd
Taylor Controls Ltd
Taylor-Short & Mason Ltd
Teddington Industrial Equipment Ltd
Thermocontrol Installations Co Ltd
Vacuum Industrial Applications Ltd
Western Detail Mfrs Ltd

COUNTERS—ADD-ON
★ Circle *No 659* on reply card
Armstrong Whitworth Aircraft Ltd, Sir W. G.
Elcontrol Ltd
Ericsson Telephones Ltd
Labgear Ltd
Lancashire Dynamo Electronic Products Ltd
McKellen Automation Ltd
Mullard Ltd
Panax Equipment Ltd
Pye Ltd
Racal Engineering Ltd
Rank Cintel Ltd
Research & Control Instruments Ltd
Stonebridge Electrical Co Ltd
Trumeter Co Ltd

COUNTERS—BATCH
★ Circle *No 660* on reply card
Airmec Ltd
Allied Electronics Ltd
Armstrong Whitworth Aircraft Ltd, Sir W. G.
British Northern Electrical Appliances Ltd
British Thomson-Houston Co Ltd, The
Ekco Electronics Ltd
Elcontrol Ltd
Ericsson Telephones Ltd
Labgear (Cambridge) Ltd
Lancashire Dynamo Electronic Products Ltd
Livingston Laboratories Ltd
Lock & Co Ltd, A. M.
Londex Ltd
McKellen Automation Ltd
Mullard Ltd
Pye Ltd
Racal Engineering Ltd
Rank Cintel Ltd
Spembly Ltd
Stonebridge Electrical Co Ltd
Trumeter Co Ltd
Venner Ltd

COUNTERS—FAST NEUTRON
★ Circle *No 661* on reply card
Ekco Electronics Ltd
Ericsson Telephones Ltd
General Radiological Ltd
Isotope Developments Ltd
Leland Instruments Ltd
Nuclear Enterprises (GB) Ltd
Plessey Nucleonics Ltd
20th Century Electronics Ltd

COUNTERS—GEIGER-MULLER
★ Circle *No 662* on reply card
Airmec Ltd
B & K Laboratories Ltd
Dynatron Radio Ltd
Ekco Electronics Ltd
Ericsson Telephones Ltd
Falk & Co Ltd, M.
Fleming Radio (Developments) Ltd
Gamma-Rays Ltd
General Electric Co Ltd, The
General Radiological Ltd
Holiday & Hemmerdinger Ltd
Ionic Instruments (London) Ltd
Isotope Developments Ltd
Labgear Ltd
Leland Instruments Ltd
Lock & Co Ltd, A. M.
Mullard Ltd
Panax Equipment Ltd
Philips Electrical Ltd
Plessey Nucleonics Ltd
Pye Ltd
Radiation Monitors Ltd
Research & Control Instruments Ltd
Solartron Electronic Group Ltd
20th Century Electronics Ltd

COUNTERS—MECHANICAL
★ Circle *No 663* on reply card
Carter & Co Ltd, B. & F.
Counting Instruments Ltd
Ericsson Telephones Ltd
Glass Developments Ltd
Leland Instruments Ltd
Londex Ltd
McKellen Automation Ltd
Panax Equipment Ltd
Smiths Industrial Instruments Ltd
Standard Telephones & Cables Ltd
Stonebridge Electrical Co Ltd
Weyers Bros Ltd

COUNTERS—PROPORTIONAL
★ Circle *No 664* on reply card
Ekco Electronics Ltd
Ericsson Telephones Ltd
General Radiological Ltd
Holiday & Hemmerdinger Ltd
Isotope Developments Ltd
Labgear Ltd
Plessey Nucleonics Ltd
Pye Ltd
Research & Control Instruments Ltd
20th Century Electronics Ltd
West Instruments Ltd

COUNTERS—REVOLUTION
★ Circle *No 665* on reply card
Airmec Ltd
Allied Electronics Ltd
Armstrong Whitworth Aircraft Ltd, Sir W. G.
Burndept Ltd
Carter & Co Ltd, B. & F.
Counting Instruments Ltd
EMI Electronics Ltd
Labgear Ltd
Lancashire Dynamo Electronic Products Ltd
Livingston Laboratories Ltd
Lock & Co Ltd, A. M.
Mullard Ltd
Pye Ltd
Rank Cintel Ltd
Smiths Industrial Instruments Ltd
Solartron Electronic Group Ltd
Stonebridge Electrical Co Ltd
20th Century Electronics Ltd
Weyers Bros Ltd

COUNTERS—SCINTILLATION
★ Circle *No 666* on reply card
B & K Laboratories Ltd
Burndept Ltd
Ekco Electronics Ltd
Ericsson Telephones Ltd
Falk & Co Ltd, M.
Fleming Radio (Developments) Ltd
General Radiological Ltd
Isotope Developments Ltd
Labgear Ltd
Livingston Laboratories Ltd
Lock & Co Ltd, A. M.
Mervyn Instruments
Nuclear Enterprises Ltd
Panax Equipment Ltd
Plessey Nucleonics Ltd
Research & Control Instruments Ltd

DENSITOMETERS—FILM BADGE
★ Circle *No 667* on reply card
Baldwin Instrument Co Ltd
Evans Electroscienium Ltd
Ilford Ltd
Joyce, Loebl & Co Ltd
Lock & Co Ltd, A. M.

DETECTORS—LEAK
★ Circle *No 668* on reply card
British Thomson-Houston Co Ltd, The
Edwards High Vacuum Ltd
Ekco Electronics Ltd
Elliott Bros (London) Ltd
Ferranti Ltd
General Electric Co Ltd, The
Infra-Red Development Co Ltd, The
Leybold Vacuum Sales Ltd
Livingston Laboratories Ltd
NGN Electrical Ltd
Solartron Electronic Group Ltd
Sunvic Controls Ltd
20th Century Electronics Ltd

DISCRIMINATOR UNITS
★ Circle *No 669* on reply card
Ericsson Telephones Ltd
Labgear Ltd
Lock & Co Ltd, A. M.

DOORS—HEAVY SHIELDING (*See Section 5*)

DOSERATE METERS
★ Circle *No 670* on reply card
Baldwin Instruments Co Ltd
Ekco Electronics Ltd
Falk & Co Ltd, M.
General Radiological Ltd
Isotope Developments Ltd
Labgear Ltd
Panax Equipment Ltd
Plessey Nucleonics Ltd

DOSIMETER CHARGING UNITS
★ Circle *No 671* on reply card
Baldwin Instrument Co Ltd
Dowty Nucleonics Ltd
Elliott Brothers (London) Ltd
Ericsson Telephones Ltd
Falk & Co Ltd, M.
General Radiological Ltd
Isotope Developments Ltd
Lock & Co Ltd, A. M.
Plessey Nucleonics Ltd
Rank Cintel Ltd
Rank Precision Industries Ltd
Solus-Schall Ltd
Stephen & Co Ltd, R. A.

DOSIMETERS—QUARTZ FIBRE
★ Circle *No 672* on reply card
Baldwin Instrument Co Ltd
Elliott Brothers (London) Ltd
Falk & Co Ltd, M.
Gamma-Rays Ltd
Isotope Developments Ltd
Lock & Co Ltd, A. M.
McKellen Automation Ltd
Mullard Ltd
Rank Precision Industries Ltd
Research & Control Instruments Ltd
Salford Electrical Instruments Ltd
Solartron Electronic Group Ltd
Solus-Schall Ltd
Stephen & Co Ltd, R. A.

DRUMS—WASTE DISPOSAL
★ Circle *No 673* on reply card
Harris (Birmingham) Ltd, F. & R. M.
Reads Ltd
Robertson & Ferguson Ltd
Western Detail Mfrs Ltd

DRY BOXES (*See Glove Boxes*)

ELECTROMETERS—VIBRATING REED
★ Circle *No 674* on reply card
Ekco Electronics Ltd
Electronic Instruments Ltd
Ericsson Telephones Ltd
Honeywell-Brown Ltd
Kent Ltd, George
Mullard Ltd
Richmond Instrument Co Ltd

ELECTROMAGNETS
★ Circle *No 675* on reply card
Allen & Co Ltd, Edgar
Ayling Nuclear Equipment Co
B & K Laboratories Ltd
Electro Methods Ltd
English Steel Corporation Ltd
General Electric Co Ltd, The
Hendrey Relays Ltd
Magnetic Equipment Co Ltd, The
Metropolitan-Vickers Electrical Co Ltd
Newport Instruments Ltd
Salford Electrical Instruments Ltd
Westool Ltd

ELUTRIATORS
★ Circle *No 676* on reply card
Cuthbert Ltd, Ralph
Darton & Co Ltd, F.
Griffin & George Ltd
Sharples Centrifuges Ltd

EXTENSOMETERS
★ Circle *No 677* on reply card
Baty & Co Ltd, J. E.
Cambridge Instrument Co Ltd
CNS Instruments Ltd
Falk & Co Ltd, M.
Solex (Gauges) Ltd
Tensometer Ltd
Western Detail Mfrs Ltd

FILTERS—AIR (*See Section 1*)

FILTERS—CERAMIC
★ Circle *No 678* on reply card
Aerox Ltd
APV Co Ltd, The
Baird & Tatlock (London) Ltd
Cuthbert Ltd, Ralph
Doulton Industrial Porcelains Ltd
Laboratory Apparatus & Glass Blowing Co
Sintered Products Ltd
Thermal Syndicate Ltd, The (Fused Silica)
Vokes Ltd
Williams & James (Engineers) Ltd

FILTERS—CHEMICAL
★ Circle *No 679* on reply card
Aerox Ltd
Ashworth & Parker Ltd
Baird & Tatlock (London) Ltd
Carlson Ltd, John D.
Cuthbert Ltd, Ralph
Davey, Paxman & Co Ltd
Doulton Laboratory Porcelains Ltd
Endecotts (Filters) Ltd
Extrudex Ltd
Hathernware Ltd
Laboratory Apparatus & Glass Blowing Co
Quickfit & Quartz Ltd
Rediweld Ltd
Sharples Centrifuges Ltd
Sintered Products Ltd
Western Detail Mfrs Ltd

FILTERS—POROUS METAL
★ Circle *No 680* on reply card
Firkins Ltd, G. & A.
Hindle & Sons Ltd, Joshua
Metal & Plastic Compacts Ltd (Stainless Steel, Cupronickel Alloys)
Norgren Ltd., C. A.
Palatine Tool & Engineering Co (Surbiton) Ltd
Sintered Products Ltd

FILTERS—SINTERED GLASS
★ Circle *No 681* on reply card
Baird & Tatlock (London) Ltd
Brinkman Ltd, E.
Cuthbert Ltd, Ralph
Gallenkamp & Co Ltd, A.
Griffin & George Ltd
Jobling & Co Ltd, James
Loughborough Glass Co Ltd
Palatine Tool & Engineering Co (Surbiton) Ltd
Quickfit & Quartz, Ltd
QVF Ltd
Towers & Co Ltd, J. W.

FILTER PAPERS
★ Circle *No 682* on reply card
Baird & Tatlock (London) Ltd
Barcham Green Ltd, J.
Gallenkamp & Co Ltd, A.
General Chemical & Pharmaceutical Co Ltd, The
Griffin & George Ltd
Hospital & Laboratory Supplies Ltd
Laboratory Apparatus & Glass Blowing Co Ltd
Loughborough Glass Co Ltd
Shandon Scientific Co Ltd
Stream-Line Filters Ltd
Towers & Co Ltd, J. W.
Vicsons Ltd

FISSION CHAMBERS
★ Circle *No 683* on reply card
Ekco Electronics Ltd
Plessey Nucleonics Ltd
20th Century Electronics Ltd

FLAW DETECTORS—MAGNETIC
★ Circle *No 684* on reply card
Babcock & Wilcox Ltd
Falk & Co Ltd, M.
General Electric Co Ltd, The
General Radiological Ltd
Glass Developments Ltd
Lancashire Dynamo Electronic Products Ltd
Magnetic Equipment Co Ltd, The
Metropolitan-Vickers Electrical Co Ltd
Philips Electrical Ltd

FLAW DETECTORS—ULTRASONIC
★ Circle *No 685* on reply card
Babcock & Wilcox Ltd
Cawkell Research & Electronics Ltd
Cossor Instruments Ltd
Dawe Instruments Ltd
Falk & Co Ltd, M.
General Electric Co Ltd, The
Glass Developments Ltd
Kelvin & Hughes Ltd
Kelvin & Hughes (Industrial) Ltd
Livingston Laboratories Ltd
Solus-Schall Ltd
Ultrasonics Ltd

FLOW METERS—GAS
★ Circle *No 686* on reply card
Appleby & Ireland Ltd
Baird & Tatlock (London) Ltd
Elliott Bros (London) Ltd
Evershed & Vignoles Ltd
Gallenkamp & Co Ltd, A.
Gordon & Co Ltd, James
Griffin & George Ltd
Honeywell-Brown Ltd
Hopkin & Co Ltd, F.
Hutcheon Duthie & Son Ltd, R.
Kent, Ltd, George
Metropolitan-Vickers Electrical Co Ltd
Parkinson & Cowan Ltd
Quickfit & Quartz Ltd
QVF Ltd
Rotameter Manufacturing Co Ltd

FLOW METERS—GAS—*continued*
Ryder & Co (Manchester) Ltd, Thomas
Solartron Electronic Group Ltd
Sunvic Controls Ltd
Taylor Controls Ltd
Thermocontrol Installations Co Ltd
Thompson Instrument Co Ltd, John

FLOW METERS—LIQUID
★ Circle *No 687* on reply card
Alto Instruments (GB) Ltd
Appleby & Ireland Ltd
Baird & Tatlock (London) Ltd
Dowty Nucleonics Ltd
Edwards High Vacuum Ltd
Elliott Bros (London) Ltd
Evershed & Vignoles Ltd
Fielden Electronics Ltd
Firth Cleveland Instruments Ltd
Gallenkamp & Co Ltd, A.
Glenfield & Kennedy Ltd
Gloster Technical Developments Ltd
Gordon & Co Ltd, James
Griffin & George Ltd
Hindle & Sons Ltd, Joshua
Honeywell-Brown Ltd
Hopkin & Co Ltd, F.
Integral Ltd
Kelvin & Hughes (Industrial) Ltd
Kent Ltd, George
Liquid Systems Ltd
Measurement Ltd
Monitor Patent Safety Devices Ltd
Parkinson & Cowan Ltd
QVF Ltd
Rotameter Manufacturing Co Ltd
Ryder & Co (Manchester) Ltd, Thomas
Shandon Scientific Co Ltd
Simmonds Aerocessories Ltd
Taylor Controls Ltd
Taylor-Short & Mason Ltd
Tylors of London Ltd
Thermocontrol Installations Co Ltd
Thompson Instrument Co Ltd, John
Hindle & Sons Ltd, Joshua

FLOW METERS—LIQUID METAL
★ Circle *No 688* on reply card
Alto Instruments (GB) Ltd
Appleby & Ireland Ltd
Palatine Tool & Engineering Co (Surbiton) Ltd
Ryder & Co (Manchester) Ltd, Thomas
Thermocontrol Installations Co Ltd

FLUORIMETERS
★ Circle *No 689* on reply card
Baird & Tatlock (London) Ltd
Evans Electroselenium Ltd
Griffin & George Ltd

FLUX SCANNING APPARATUS
★ Circle *No 690* on reply card
Chatwood-Milner Ltd
Elliott Bros (London) Ltd
General Radiological Ltd
Plessey Nucleonics Ltd
Sunvic Controls Ltd

FUME CUPBOARDS
★ Circle *No 691* on reply card
Baird & Tatlock (London) Ltd
Bullows & Sons Ltd, Alfred
Controlled Heat & Air Ltd
Cygnet Joinery Ltd
Gallenkamp & Co Ltd, A.
Griffin & George Ltd
Hall & Co Ltd, Matthew
Hathernware Ltd
Hospital & Laboratory Supplies Ltd
Mancuna Engineering Ltd
Marine & Industrial Plastics Ltd
Mathews & Yates Ltd
Opperman Ltd, S. E.
Owen Power Plant Co
Rediweld Ltd
Scientific Furnishings Ltd
Supervents Ltd
Towers & Co Ltd, J. W.
Tupholme & Co Ltd, George E.
Visco Engineering Co Ltd
Weatherfoil Heating Systems Ltd

FURNACES—CRUCIBLE
★ Circle *No 692* on reply card
AEW Ltd
Baird & Tatlock (London) Ltd
Barlow-Whitney Ltd
Catterson-Smith Ltd, R. M.
Cuthbert Ltd, Ralph
Electric Furnace Co Ltd
Electrothermal Engineering Ltd
Fleischmann (London) Ltd
Gallenkamp & Co Ltd, A.
General Electric Co Ltd, The
Griffin & George Ltd
Head Wrightson Processes Ltd
Johnson, Matthey & Co Ltd
Morgan Crucible Co Ltd, The
River Chemical Co Ltd
Scientific Furnishings Ltd
Towers & Co Ltd, J. W.

FURNACES—HIGH FREQUENCY
★ Circle *No 693* on reply card
AEW Ltd
ASEA Electric Ltd
Electric Furnace Co Ltd
Fleischmann (London) Ltd
General Electric Co Ltd, The
Leybold Vacuum Sales Ltd
Metropolitan-Vickers Electrical Co Ltd
Vacuum Industrial Applications Ltd
Western Detail Mfrs Ltd

FURNACES—MUFFLE
★ Circle *No 694* on reply card
AEW Ltd
Baird & Tatlock (London) Ltd
Barlow-Whitney Ltd
Carborundum Co Ltd, The
Catterson-Smith Ltd, R. M.
Cuthbert Ltd, Ralph

FURNACES—MUFFLE—*continued*
Electric Furnace Co Ltd
Electrothermal Engineering Ltd
Gallenkamp & Co Ltd, A.
General Electric Co Ltd, The
Glass Developments Ltd
Griffin & George Ltd
Johnson, Matthey & Co Ltd
River Chemical Co Ltd
Scientific Furnishings Ltd
Spembly Ltd
Towers & Co Ltd, J. W.

FURNACES—TUBE
★ Circle *No 695* on reply card
AEW Ltd
Baird & Tatlock (London) Ltd
Barlow-Whitney Ltd
Catterson-Smith Ltd, R. M.
Cuthbert Ltd, Ralph
Electric Furnace Co Ltd
Electrothermal Engineering Ltd
Gallenkamp & Co Ltd, A.
General Electric Co Ltd, The
Griffin & George Ltd
Head Wrightson Processes Ltd
Johnson, Matthey & Co Ltd
River Chemical Co Ltd
Scientific Instruments Ltd
Spembly Ltd
Towers & Co Ltd, J. W.

FURNACES—VACUUM
★ Circle *No 696* on reply card
AEW Ltd
Butterfield Ltd, W. P.
Edwards High Vacuum Ltd
Electric Furnace Co Ltd
Fleischmann (London) Ltd
General Electric Co Ltd, The
Leybold Vacuum Sales Ltd
Metropolitan-Vickers Electrical Co Ltd
NGN Electrical Ltd
Pulsometer Engineering Co Ltd, The
Spembly Ltd
Vacuum Industrial Applications Ltd
Western Detail Mfrs Ltd

GAS SAMPLING PLANT
★ Circle *No 697* on reply card
Armstrong Siddeley Motors Ltd
Dowty Nucleonics Ltd
Elliott Bros (London) Ltd
General Radiological Ltd
Hall & Co Ltd, Matthew
Plessey Nucleonics Ltd
Reavell & Co Ltd
Sunvic Controls Ltd
Talbot Stead Tube Co Ltd

GAUGES—DIFFERENTIAL PRESSURE
★ Circle *No 698* on reply card
Accurate Recording Instrument Co Ltd
Appleby & Ireland Ltd
Barnet Instruments Ltd
British Steam Specialties Ltd
Cambridge Instrument Co Ltd
Dewrance & Co Ltd
Darton & Co Ltd, F.
Elliott Bros (London) Ltd
Evershed & Vignoles Ltd
Fielden Electronics Ltd
Gordon & Co Ltd, James
Honeywell-Brown Ltd
Hopkinsons Ltd
KDG Instruments Ltd
Kelvin & Hughes (Industrial) Ltd
Kent Ltd, George
Leybold Vacuum Sales Ltd
Negretti & Zambra Ltd
Payne & Griffiths Ltd
Salford Electrical Instruments Ltd
Solartron Electronic Group Ltd
Sunvic Controls Ltd
Taylor-Short & Mason Ltd
Thermocontrol Installations Co Ltd
Thompson Instrument Co Ltd, John

GAUGES—IONIZATION
★ Circle *No 699* on reply card
Appleby & Ireland Ltd
Edwards High Vacuum Ltd
Dowty Nucleonics Ltd
Electronic Instruments Ltd
Fleischmann (London) Ltd
Isotope Developments Ltd
Leybold Vacuum Sales Ltd
NGN Electrical Ltd
Siemens Edison Swan Ltd
Vacuum Industrial Applications Ltd

GAUGES—LIQUID LEVEL NUCLEONIC
★ Circle *No 700* on reply card
Accurate Recording Instrument Co Ltd
Appleby & Ireland Ltd
Baldwin Instrument Co Ltd
Dewrance & Co Ltd
Ekco Electronics Ltd
Firth Cleveland Instruments Ltd
Ionic Instruments (London) Ltd
Isotope Developments Ltd
KDG Instruments Ltd
Lock & Co Ltd, A. M.
Salford Electrical Instruments Ltd
Smiths Industrial Instruments Ltd
Sunvic Controls Ltd
Thompson Instrument Co Ltd, John

GAUGES—LIQUID LEVEL (OTHER)
★ Circle *No 701* on reply card
Accurate Recording Instrument Co Ltd
Appleby & Ireland Ltd
Butterworth Bros Ltd
British Steam Specialties Ltd
Elcontrol Ltd
Elliott Bros (London) Ltd
Evershed & Vignoles Ltd
Fielden Electronics Ltd
General Radiological Ltd
Gordon & Co Ltd, James
Hindle & Sons Ltd, Joshua
Honeywell-Brown Ltd

GAUGES—LIQUID LEVEL (OTHER)—*continued*
Hobson Ltd, H. M.
Ionic Instruments (London) Ltd
Kent Ltd, George
Klinger Ltd, Richard
Lancashire Dynamo Electrical Products Ltd
Lock & Co Ltd, A. M.
Negretti & Zambra Ltd
Rotameter Manufacturing Co Ltd
Salford Electrical Instruments Ltd
Simmonds Aerocessories Ltd
Sunvic Controls Ltd
Taylor-Short & Mason Ltd
Thermocontrol Installations Co Ltd
Whessoe Ltd
Thompson Instrument Co Ltd, John

GAUGES—PRESSURE
★ Circle *No 702* on reply card
Accurate Recording Instrument Co Ltd
Appleby & Ireland Ltd
Babcock & Wilcox Ltd
Barnet Instruments Ltd
British Rototherm Co Ltd, The
British Steam Specialties Ltd
Cambridge Instrument Co Ltd
Darton & Co Ltd, F.
Dewrance & Co Ltd
Elliott Bros (London) Ltd
Fielden Electronics Ltd
Fleischmann (London) Ltd
Gordon & Co Ltd, James
Honeywell-Brown Ltd
Hobson Ltd, H. M.
Hopkinsons Ltd
KDG Instruments Ltd
Kent Ltd, George
Negretti & Zambra Ltd
Payne & Griffiths Ltd
Salford Electrical Instruments Ltd (Moving Coil)
Sangamo Weston Ltd
Savage & Parsons Ltd
Shandon Scientific Co Ltd
Smith Industrial Instruments Ltd
Solartron Electronic Group Ltd
Sunvic Controls Ltd
Taylor-Short & Mason Ltd
Thermocontrol Installations Co Ltd
Thompson Instrument Co Ltd, John

GAUGES—STRAIN
★ Circle *No 703* on reply card
Appleby & Ireland Ltd
Elliott Brothers (London) Ltd
General Electric Co Ltd, The
Hilger & Watts Ltd
Honeywell-Brown Ltd
Kelvin & Hughes (Industrial) Ltd
Leland Instruments Ltd
Philips Electrical Ltd
Salford Electrical Instruments Ltd
Savage & Parsons Ltd
Saunders-Roe Ltd
Shandon Scientific Co Ltd
Solartron Electronic Group Ltd
Teddington Industrial Equipment Ltd
Tinsley & Co Ltd, H.

GAUGES—THICKNESS OR DENSITY NUCLEONIC
★ Circle *No 704* on reply card
Appleby & Ireland Ltd
Baldwin Instrument Co Ltd
Davy & United Engineering Co Ltd
Dawe Instruments Ltd
Ekco Electronics Ltd
Isotope Developments Ltd
Kelvin & Hughes (Industrial) Ltd
Lock & Co Ltd, A. M.
Philips Electrical Ltd

GAUGES VACUUM
★ Circle *No 705* on reply card
Accurate Recording Instrument Co Ltd
Appleby & Ireland Ltd
Barnet Instruments Ltd
British Rototherm Co Ltd, The
British Steam Specialties Ltd
Cambridge Instrument Co Ltd
Darton & Co Ltd, F.
Dewrance & Co Ltd
Edwards High Vacuum Ltd
Elliott Bros (London) Ltd
Fleischmann (London) Ltd
General Electric Co Ltd, The
Glass Developments Ltd
Honeywell-Brown Ltd
KDG Instruments Ltd
Kent Ltd, George
Leybold Vacuum Sales Ltd
Metropolitan-Vickers Electrical Co Ltd
Negretti & Zambra Ltd
NGN Electrical Ltd
Payne & Griffiths Ltd
Pulsometer Engineering Co Ltd, The
Salford Electrical Instruments Ltd
Smiths Industrial Instruments Ltd
Taylor-Short & Mason Ltd
Thermocontrol Installations Co Ltd
Vacuum Industrial Applications Ltd

GAUGES—WATER
★ Circle *No 706* on reply card
Accurate Recording Instrument Co Ltd
Appleby & Ireland Ltd
Babcock & Wilcox Ltd
Barnet Instruments Ltd
British Steam Specialties Ltd
Butterworth Bros Ltd
Darton & Co Ltd, F.
Dewrance & Co Ltd
Elliott Brothers (London) Ltd
Gordon & Co Ltd, James
Honeywell-Brown Ltd
Hopkinsons Ltd
KDG Instruments Ltd
Kent Ltd, George
Klinger Ltd, Richard
Payne & Griffiths Ltd
Salford Electrical Instruments Ltd
Thermocontrol Installations Co Ltd
Thompson Instrument Co Ltd, John

GEIGER-MULLER TUBES—
(See Counters—Geiger-Müller)

GENERATORS—COCKCROFT-WALTON
★ Circle *No 707* on reply card
Hivolt Ltd
Philips Electrical Ltd

GENERATORS—HIGH FREQUENCY
★ Circle *No 708* on reply card
Airmec Ltd
British Physical Laboratories
Holiday & Hemmerdinger Ltd
Lancashire Dynamo Electronic Products Ltd
Livingston Laboratories Ltd
Newton Victor Ltd
Philips Electrical Ltd
Redifon Ltd
Standard Telephones & Cables Ltd

GENERATORS—PULSE
★ Circle *No 709* on reply card
Allied Electronics Ltd
B & K Laboratories Ltd
British Physical Laboratories
Cawkell Research & Electronics Ltd
Dowty Nucleonics Ltd
Dynatron Radio Ltd
EMI Electronics Ltd
Ericsson Telephones Ltd
General Electric Co Ltd, The
Ferranti Ltd
Fleming Radio (Developments) Ltd
General Radiological Ltd
Lancashire Dynamo Electronic Products Ltd
Leland Instruments Ltd
Livingston Laboratories Ltd
Lyons Ltd, Claude (agents for General Radio Co USA)
Mullard Ltd
Nagard Ltd
Newton Victor Ltd
Panax Equipment Ltd
Rank Cintel Ltd
Research & Control Instruments Ltd
Servomex Controls Ltd
Solartron Electronic Group Ltd
Wayne Kerr Laboratories Ltd
Western Detail Mfrs Ltd

GENERATORS—SAW TOOTH
★ Circle *No 710* on reply card
Allied Electronics Ltd
B & K Laboratories Ltd
Cawkell Research & Electronics Ltd
General Radiological Ltd
Lancashire Dynamo Electronic Products Ltd
Leland Instruments Ltd
Livingston Laboratories Ltd
Lyons Ltd, Claude
Mullard Ltd
Rank Cintel Ltd
Research & Control Instruments Ltd
Servomex Controls Ltd

GENERATORS—SQUARE WAVE
★ Circle *No 711* on reply card
Allied Electronics Ltd
B & K Laboratories Ltd
Cawkell Research & Electronics Ltd
EMI Electronics Ltd
General Radiological Ltd
Glass Developments Ltd
Lancashire Dynamo Electronic Products Ltd
Leland Instruments Ltd
Livingston Laboratories Ltd
Lyons Ltd, Claude
Mullard Ltd
Nagard Ltd
Panax Equipment Ltd
Rank Cintel Ltd
Research & Control Instruments Ltd
Servomex Controls Ltd
Solartron Electronic Group Ltd
Venner Electronics Ltd

GENERATORS—ULTRASONIC
★ Circle *No 712* on reply card
B & K Laboratories Ltd
Cawkell Research & Electronics Ltd
General Radiological Ltd
Glass Developments Ltd
Kelvin & Hughes Ltd
Lancashire Dynamo Electronic Products Ltd
Leland Instruments Ltd
Livingston Laboratories Ltd
Mullard Ltd
Solartron Electronic Group Ltd
Ultrasonics Ltd

GENERATORS—VAN DE GRAAFF
★ Circle *No 713* on reply card
Hivolt Ltd
High Voltage Servicing Co Ltd (sole UK distributors for HVE Corpn USA)
Leybold Vacuum Sales Ltd

GLASS—LEAD
★ Circle *No 714* on reply card
Andrews, Cuthbert
Butterworth Bros Ltd
Chance Bros Ltd
Chance-Pilkington Optical Works
Laboratory Apparatus & Glass Blowing Co
Metropolitan-Vickers Electrical Co Ltd
Newton Victor Ltd
Optical Works Ltd, The
QVF Ltd
Savage & Parsons Ltd

GLASS—STABILIZED OPTICAL
★ Circle *No 715* on reply card
Andrews, Cuthbert
Chance Bros Ltd
Chance-Pilkington Optical Works
Dallmeyer Ltd, J. H.
QVF Ltd
Ross Ensign Ltd

GLASSWORKING LATHES
★ Circle *No 716* on reply card
Edwards High Vacuum Ltd
Glass Developments Ltd

GLOVE BOXES—STANDARD PRODUCTS
★ Circle *No 717* on reply card
Ayling Nuclear Equipment Co
BMB (Sales) Ltd
Chatwood-Milner Ltd
Falk & Co Ltd, M.
HL Instruments Ltd
Hall & Co Ltd, Matthew
Marine & Industrial Plastics Ltd
Mendip (Chemical Engineering) Ltd
Ramsey Engineering Co Ltd
Savage & Parsons Ltd
South London Electrical Equipment Co Ltd
Towers & Co Ltd, J. W.
Townson & Mercer Ltd
Weatherfoil Heating Systems Ltd
Wilson & Partners Ltd, A. C.

GLOVE BOXES—SPECIAL ORDER
★ Circle *No 718* on reply card
Ayling Nuclear Equipment Co
BMB (Sales) Ltd
Brown & Co Ltd, E. G.
Carrier Engineering Co Ltd
Chatwood-Milner Ltd
Falk & Co Ltd, M.
General Radiological Ltd
Graviner Mfg Co Ltd
HL Instruments Ltd
Hall & Co Ltd, Matthew
Marine & Industrial Plastics Ltd
Mendip (Chem. Eng.) Ltd
Opperman Ltd, S. E.
Palatine Tool & Engineering Co (Surbiton) Ltd
Savage & Parsons Ltd
South London Electrical Equipment Co Ltd
Spembly Ltd
Thermo-Plastics Ltd
Townson & Mercer Ltd
Ward & Co Ltd, Thomas W.
Weatherfoil Heating Systems Ltd
Western Detail Mfrs Ltd
Wilson & Partners Ltd, A. C.

GLOVE BOX GAUNTLETS
★ Circle *No 719* on reply card
Chichester Rubber Co Ltd, The
Falk & Co Ltd, M.
South London Electrical Equipment Co Ltd
Towers & Co Ltd, J. W.
Veedip Ltd

HARDNESS TESTING INSTRUMENTS
★ Circle *No 720* on reply card
Nash & Thompson Ltd
Shandon Scientific Co Ltd
Solartron Electronic Group Ltd

HEATERS—PIPE
★ Circle *No 721* on reply card
Electrothermal Engineering Ltd
Isopad Ltd
Stabilag Co Ltd, The
Towers & Co Ltd, J. W.

HEATERS—RADIOFREQUENCY
★ Circle *No 722* on reply card
B & K Laboratories Ltd
British Thomson-Houston Co Ltd, The
EMI Electronics Ltd
English Electric Co Ltd, The
General Electric Co Ltd, The
Incandescent Heat Co Ltd
Isopad Ltd
Lancashire Dynamo Electronic Products Ltd
Leland Instruments Ltd
Metalectric Furnaces Ltd
Metropolitan-Vickers Electrical Co Ltd
Radio Heaters Ltd
Western Detail Mfrs Ltd

HEATERS—SURFACE
★ Circle *No 723* on reply card
Electrothermal Engineering Ltd
Isopad Ltd
Spembly Ltd
Stabilag Co Ltd, The
Towers & Co Ltd, J. W.
Worthington-Simpson Ltd

HEATING TAPES
★ Circle *No 724* on reply card
Baird & Tatlock (London) Ltd
Electrothermal Engineering Ltd
Gallenkamp & Co Ltd, A.
Griffin & George Ltd
Hospital & Laboratory Supplies Ltd
Isopad Ltd
Laboratory Apparatus & Glass Blowing Co
Stabilag Co Ltd, The
Towers & Co Ltd, J. W.
Vicsons Ltd

INSULATION TESTERS
★ Circle *No 725* on reply card
Airmec Ltd
Allied Electronics Ltd
British Physical Laboratories
Electronic Instruments Ltd
English Electric Co Ltd, The
Evershed & Vignoles Ltd
Gresham Transformers Ltd
General Electric Co Ltd, The
Rank Cintel Ltd
Record Electrical Co Ltd, The
Research & Control Instruments Ltd
Salford Electrical Instruments Ltd
Solartron Electronic Group Ltd
Tinsley & Co Ltd, H.
White Electrical Instrument Co Ltd

INTROSCOPES
★ Circle *No 726* on reply card
Allen & Co, P. W.
Foster Instrument Co Ltd
Optical Works Ltd

IONIZATION CHAMBERS—ALPHA
★ Circle *No 727* on reply card
Baldwin Instrument Co Ltd
Plessey Nucleonics Ltd
Sunvic Controls Ltd

IONIZATION CHAMBERS—ALPHA—*continued*
Vacuum Industrial Applications Ltd
Western Detail Mfrs Ltd

IONIZATION CHAMBERS—BETA
★ Circle *No 728* on reply card
Baldwin Instrument Co Ltd
General Radiological Ltd
Isotope Developments Ltd
Palatine Tool & Engineering Co (Surbiton) Ltd
Plessey Nucleonics Ltd
Tinsley & Co Ltd, H.
Vacuum Industrial Applications Ltd
Western Detail Mfrs Ltd

IONIZATION CHAMBERS—ALPHA-BETA
★ Circle *No 729* on reply card
Baldwin Instrument Co Ltd
Plessey Nucleonics Ltd
Western Detail Mfrs Ltd

IONIZATION CHAMBERS—GAMMA
★ Circle *No 730* on reply card
Baldwin Instrument Co Ltd
General Radiological Ltd
Isotope Developments Ltd
Plessey Nucleonics Ltd
Vacuum Industrial Applications Ltd
Western Detail Mfrs Ltd

IONIZATION CHAMBERS—NEUTRON
★ Circle *No 731* on reply card
General Radiological Ltd
Isotope Developments Ltd
Plessey Nucleonics Ltd
Research & Control Instruments Ltd
20th Century Electronics Ltd
Vacuum Industrial Applications Ltd

IONIZATION CHAMBERS—REACTOR
★ Circle *No 732* on reply card
General Radiological Ltd
Isotope Developments Ltd
Plessey Nucleonics Ltd
Research & Control Instruments Ltd
20th Century Electronics Ltd
Vacuum Industrial Applications Ltd

IRRADIATION SERVICES
★ Circle *No 733* on reply card
Metropolitan-Vickers Electrical Co Ltd
Nuclear Engineering Ltd
TI Nuclear Engineering Ltd

ISOTOPES
★ Circle *No 734* on reply card
Falk & Co Ltd, M.
Radiochemical Centre (UKAEA) (Radioactive)
20th Century Electronics Ltd (Radioactive)

ISOTOPE CONTAINERS—(*See Containers—Isotope*)

KICKSORTERS—(*See Analysers—Pulse Amplitude*)

LABORATORY EQUIPMENT CONTRACTORS
★ Circle *No 735* on reply card
Allied Electronics Ltd (electronic)
Baird & Tatlock (London) Ltd
Barytes (Shielding Products) Ltd
Cuthbert Ltd, Ralph
Cygnet Joinery Ltd
Dynatron Radio Ltd
Electrothermal Engineering Ltd
Engis Ltd (Diamond Abrasive Mfrs)
Extrudex Ltd
Falk & Co Ltd, M.
Gallenkamp & Co Ltd, A.
Gardner & Co Ltd, Henry
Griffin & George Ltd
Hall & Co Ltd, Matthew
Harris (Birmingham) Ltd, F. & R. M.
Hospital & Laboratory Supplies Ltd
Ionic Instruments (London) Ltd
Isotope Developments Ltd
Laboratory Apparatus & Glass Blowing Co
Lang London Ltd
Leland Instruments Ltd
Lock & Co Ltd, A. M.
Loughborough Glass Co Ltd
Marine & Industrial Plastics Ltd
QVF Ltd
Pye Ltd
Redlweld Ltd
River Chemical Co Ltd
Scientific Furnishings Ltd
Solartron Electronic Group Ltd
Spembly Ltd
Stabilag Co Ltd, The
Sturtevant Engineering Co Ltd
Tinsley & Co Ltd, H.
Towers & Co Ltd, J. W.
Townson & Mercer Ltd
Vicsons Ltd
Western Detail Mfrs Ltd

LEAD—BLOCKS
★ Circle *No 736* on reply card
Appleton & Howard Ltd
Associated Lead Manufacturers Ltd
Blundell & Crompton Ltd
British Lead Mills Ltd
Ekco Electronics Ltd
Falk & Co Ltd, M.
ERD Engineering Co Ltd
General Radiological Ltd
Grazebrook Ltd, M. & W.
Grey & Marten Ltd
Hull & Sons Ltd, F.
Isotope Developments Ltd
Labgear Ltd
Lock & Co Ltd, A. M.
Mills Packard Construction Co Ltd
Nuclear Engineering Ltd
Randall Ltd, P. E.
Savage & Parsons Ltd
Western Detail Mfrs Ltd

LEAD—CASTLES
★ Circle *No 737* on reply card
Appleton & Howard Ltd
Associated Lead Manufacturers Ltd

LEAD—CASTLES—*continued*
Britisn Lead Mills Ltd
Dynatron Radio Ltd
Ekco Electronics Ltd
ERD Engineering Co Ltd
General Radiological Ltd
Grey & Marten Ltd
Hull & Sons Ltd, F.
Isotope Developments Ltd
Labgear Ltd
Lock & Co Ltd, A. M.
Mills Packard Construction Co Ltd
Nuclear Engineering Ltd
Panax Equipment Ltd
Randall Ltd, P. E.
Savage & Parsons Ltd
Western Detail Mfrs Ltd

LEAD—CONTAINERS
★ Circle *No 738* on reply card
Appleton & Howard Ltd
Associated Lead Manufacturers Ltd
British Lead Mills Ltd
Ekco Electronics Ltd
ERD Engineering Co Ltd
Falk & Co Ltd, M.
General Radiological Ltd
Grey & Marten Ltd
Hull & Sons Ltd, F.
Isotope Developments Ltd
Labgear Ltd
Lock & Co Ltd, A. M.
Mills Packard Construction Co Ltd
Newton Victor Ltd
Panax Equipment Ltd
Randall Ltd, P. E.
Savage & Parsons Ltd
Western Detail Mfrs Ltd

LOAD CELLS
★ Circle *No 739* on reply card
B. & K Laboratories Ltd
Davy & United Engineering Co Ltd
Elliott Bros (London) Ltd
Research & Control Instruments Ltd
Salford Electrical Instruments Ltd

MAGNETS—PERMANENT
★ Circle *No 740* on reply card
Allen & Co Ltd, Edgar
Darwins Ltd
English Steel Corp Ltd
General Electric Co Ltd, The
Griffin & George Ltd
Magnetic Equipment Co Ltd, The
Mullard Ltd

MANIPULATORS—MASTER SLAVE
★ Circle *No 741* on reply card
Hobson Ltd, H. M.
General Electric Co Ltd
Muirhead & Co Ltd
Palatine Tool & Engineering Co (Surbiton) Ltd
Pye Ltd
Savage & Parsons Ltd
Western Detail Mfrs Ltd
Wilson & Partners Ltd, A. C.

MANOMETERS—ELECTRONIC
★ Circle *No 742* on reply card
Appleby & Ireland Ltd
Bryans Aeroquipment Ltd
Cambridge Instrument Co Ltd
Laboratory Apparatus & Glass Blowing Co
Leybold Vacuum Sales Ltd
Solartron Electronic Group Ltd

MANOMETERS—INCLINED TUBE
★ Circle *No 743* on reply card
Appleby & Ireland Ltd
Bryans Aeroquipment Ltd
Casella & Co Ltd, C. F.
Darton & Co Ltd, F.
Griffin & George Ltd
Ionic Instruments (London) Ltd
Kent Ltd, George
Negretti & Zambra Ltd
Thompson Instrument Co Ltd, John
Towers & Co Ltd, J. W.

MANOMETERS—MERCURY
★ Circle *No 744* on reply card
Appleby & Ireland Ltd
Barnet Instruments Ltd
Bryans Aeroquipment Ltd
Budworth Ltd, David
Darton & Co Ltd, F.
Edwards High Vacuum Ltd
Elliott Brothers (London) Ltd
Evershed & Vignoles Ltd
Gallenkamp & Co Ltd, A.
Glass Developments Ltd
Griffin & George Ltd
Ionic Instruments (London) Ltd
Kelvin & Hughes Ltd
Kent Ltd, George
Leybold Vacuum Sales Ltd
Negretti & Zambra Ltd
Quickfit & Quartz Ltd
Taylor Controls Ltd
Taylor-Short & Mason Ltd
Thompson Instrument Co Ltd, John
Towers & Co Ltd, J. W.

MANOMETERS—MICRO
★ Circle *No 745* on reply card
Appleby & Ireland Ltd
Bryans Aeroquipment Ltd
Casella & Co Ltd, C. F.
Glass Developments Ltd
Griffin & George Ltd
Leybold Vacuum Sales Ltd
Nash & Thompson Ltd
Negretti & Zambra Ltd

MANOMETERS—U-TUBE
★ Circle *No 746* on reply card
Appleby & Ireland Ltd
Baird & Tatlock (London) Ltd
Bryans Aeroquipment Ltd
Budworth Ltd, David

MANOMETERS—U-TUBE—*continued*
Casella & Co Ltd, C. F.
Cuthbert Ltd, Ralph
Darton & Co Ltd, F.
Edwards High Vacuum Ltd
Elliott Brothers (London) Ltd
Gallenkamp & Co Ltd, A.
Glass Developments Ltd
Griffin & George Ltd
Ionic Instruments (London) Ltd
Kent Ltd, George
Leybold Vacuum Sales Ltd
Loughborough Glass Co Ltd
Negretti & Zambra Ltd
Pulsometer Engineering Co Ltd, The
Quickfit & Quartz Ltd
QVF Ltd
Springham & Co, G.
Thompson Instrument Co Ltd, John
Towers & Co Ltd, J. W.

MECHANICAL TESTING EQUIPMENT
★ Circle *No 747* on reply card
Avery Ltd, W. & T.
Cawkell Research & Electronics Ltd
Denison & Son Ltd, Samuel
Dexion Ltd
Electro-Hydraulics Ltd
EMI Electronics Ltd
Ionic Instruments (London) Ltd
Moore & Co Ltd, W. & E.
Scaley Engineering Ltd
Tensometer Ltd
Universal Pattern & Precision Eng Co Ltd
Weyers Bros Ltd

METERS—BTU
★ Circle *No 748* on reply card
Elliott Bros (London) Ltd
Evershed & Vignoles Ltd
Hutcheon Duthie & Son Ltd, R.
Kent Ltd, George
Thermocontrol Installations Co Ltd

METERS—CONTAMINATION
★ Circle *No 749* on reply card
Isotope Developments Ltd
Thermocontrol Installations Co Ltd

METERS—FREQUENCY
★ Circle *No 750* on reply card
Airmec Ltd
British Physical Laboratories
Elliott Bros (London) Ltd
English Electric Co Ltd, The
Ericsson Telephones Ltd
Evershed & Vignoles Ltd
Ferranti Ltd
General Electric Co Ltd, The
Honeywell-Brown Ltd
Kent Ltd, George
Lyons Ltd, Claude
Measuring Instruments (Pullin) Ltd
Racal Engineering Ltd
Record Electrical Co Ltd, The
Salford Electrical Instruments Ltd
Sangamo Weston Ltd
Stonebridge Electrical Co Ltd
Venner Ltd

METERS—GAS
★ Circle *No 751* on reply card
Baird & Tatlock (London) Ltd
Griffin & George Ltd
Honeywell-Brown Ltd
Kent Ltd, George
Parkinson & Cowan Ltd
White Electrical Instrument Co Ltd
Wright & Co Ltd, Alexander

METERS—HUMIDITY
★ Circle *No 752* on reply card
Cambridge Instrument Co Ltd
Darton & Co Ltd, F.
Dawe Instruments Ltd
Elliott Bros (London) Ltd
Honeywell-Brown Ltd
Research & Control Instruments Ltd
Taylor-Short & Mason Ltd

METERS—pH
★ Circle *No 753* on reply card
Baird & Tatlock (London) Ltd
Cambridge Instrument Co Ltd
Cuthbert Ltd, Ralph
Doran Instrument Co Ltd
Electronic Instruments Ltd
Elliott Bros (London) Ltd
General Electric Co Ltd, The
Griffin & George Ltd
Honeywell-Brown Ltd
Ionic Instruments (London) Ltd
Kent Ltd, George
Lock & Co Ltd, A. M.
McKellen Automation Ltd
Research & Control Instruments Ltd
White Electrical Instrument Co Ltd

METERS—POWER FACTOR
★ Circle *No 754* on reply card
British Thomson-Houston Co Ltd, The
English Electric Co Ltd, The
Ferranti Ltd
General Electric Co Ltd, The
Kent Ltd, George
McKellen Automation Ltd
Measuring Instruments (Pullin) Ltd
Measurement Ltd
Metropolitan-Vickers Electrical Co Ltd
Record Electrical Co Ltd, The
Reyrolle & Co Ltd, A.
Salford Electrical Instruments Ltd

METERS—REACTOR PERIOD
★ Circle *No 755* on reply card
Ekco Electronics Ltd
Elliott Bros (London) Ltd
General Radiological Ltd
Honeywell-Brown Ltd
Isotope Developments Ltd
Kent Ltd, George
Plessey Nucleonics Ltd
Sunvic Controls Ltd

METERS—REACTOR POWER LEVEL
★ Circle *No 756* on reply card
Ekco Electronics Ltd
Elliott Bros (London) Ltd
Ericsson Telephones Ltd
General Radiological Ltd
Isotope Developments Ltd
Kent Ltd, George
Plessey Nucleonics Ltd
Record Electrical Co Ltd, The

METERS—REACTOR POWER ERROR
★ Circle *No 757* on reply card
Ekco Electronics Ltd
Elliott Bros (London) Ltd
Ericsson Telephones Ltd
General Radiological Ltd
Honeywell-Brown Ltd
Kent Ltd, George
Plessey Nucleonics Ltd
Sunvic Controls Ltd

METERS—kWh
★ Circle *No 758* on reply card
Elliott Bros (London) Ltd
English Electric Co Ltd, The
Ferranti Ltd
General Electric Co Ltd, The
Kent Ltd, George
Measurement Ltd
Metropolitan-Vickers Electrical Co Ltd
Parkinson & Cowan Ltd
Stonebridge Electrical Co Ltd

MICROSCOPES—METALLURGICAL
★ Circle *No 759* on reply card
Baker of Holborn Ltd, C.
Cooke, Troughton & Simms Ltd
Cuthbert Ltd, Ralph
Gallenkamp & Co Ltd, A.
Griffin & George Ltd
Hilger & Watts Ltd
McArthur Microscopes Ltd
Prior & Co Ltd, W. R.
Shandon Scientific Co Ltd

MILLS—LABORATORY GRINDING
★ Circle *No 760* on reply card
Allen & Co Ltd, Edgar
Apex Construction Ltd
Baird & Tatlock (London) Ltd
Cornwall Mills Ltd
Cuthbert Ltd, Ralph
Doulton Industrial Porcelains Ltd
Follsain-Wycliffe Foundries Ltd
Gallenkamp & Co Ltd, A.
Griffin & George Ltd
Harris (Birmingham) Ltd, F. & R. M.
Lang London Ltd
Manesty Machines Ltd
Pascall Engineering Co Ltd, The
Scientific Furnishings Ltd
Shandon Scientific Co Ltd
Towers & Co Ltd, J. W.

MONITORS—FAST NEUTRON
★ Circle *No 762* on reply card
Burndept Ltd
Ecko Electronics Ltd
General Radiological Ltd
Isotope Developments Ltd
Nuclear Enterprises (GB) Ltd
Plessey Nucleonics Ltd

MONITORS—HAND AND FOOT
★ Circle *No 761* on reply card
EMI Electronics Ltd
Glass Developments Ltd
Leland Instruments Ltd
Mullard Ltd
Research & Control Instruments Ltd

MONITORS—PORTABLE RADIATION
★ Circle *No 763* on reply card
Airmec Ltd
Baldwin Instrument Co Ltd
Dowty Nucleonics Ltd
Ekco Electronics Ltd
Elliott Brothers (London) Ltd
Ericsson Telephones Ltd
Fleming Radio (Developments) Ltd
General Radiological Ltd
Isotope Developments Ltd
Labgear Ltd
Nicholson (Scientific Instruments) Ltd, W. B.
Nuclear Enterprises (GB) Ltd
Panax Equipment Ltd
Plessey Nucleonics Ltd
Research & Control Instruments Ltd

MONITORS—X-RAY
★ Circle *No 764* on reply card
Baldwin Instrument Co Ltd
Ekco Electronics Ltd
Fleming Radio (Developments) Ltd
Gamma-Rays Ltd
General Radiological Ltd
Labgear Ltd
Research & Control Instruments Ltd
Solus-Schall Ltd

NAMEPLATES, DIALS AND SCALES
★ Circle *No 765* on reply card
British Metal Engraving Co Ltd
Caxton Nameplate Mfg Co Ltd
John Gosheron & Co Ltd
London Name Plate Mfg Co Ltd, The
McKenna & Moore Ltd
Reliance (Nameplates) Ltd
Universal Engraving Co Ltd

NEUTRON SOURCES
★ Circle *No 766* on reply card
Research & Control Instruments Ltd
Talbot Stead Tube Co Ltd
TI Nuclear Engineering Ltd

OSCILLOGRAPHS—CATHODE RAY
★ Circle *No 767* on reply card
Airmec Ltd
Allied Electronics Ltd

OSCILLOSCOPE—CATHODE RAY—*continued*
B & K Laboratories Ltd
British Physical Laboratories
Cambridge Instrument Co Ltd
Cawkell Research & Electronics Ltd
Cossor Instruments Ltd
EMI Electronics Ltd
Ferranti Ltd
Fleming Radio Ltd
Furzehill Laboratories Ltd
General Electric Co Ltd, The
Griffin & George Ltd
Holiday & Hemmerdinger Ltd
Leland Instruments Ltd
Livingston Laboratories Ltd
Lock & Co Ltd, A. M.
Lyons Ltd, Claude (agents for Allen B Du Mont USA)
McKellen Automation Ltd
Mullard Ltd
Nagard Ltd
Parkinson & Cowan Ltd
Pye Ltd
Rank Cintel Ltd
Research & Control Instruments Ltd
Robinson & Pinrs Ltd, F. C.
Solartron Ltd
Southern Instruments, Computer Division
Taylor Electrical Instruments Ltd
20th Century Electronics Ltd (cathode ray tubes)

OVENS—LABORATORY
★ Circle *No 768* on reply card
AEW Ltd
Baird & Tatlock (London) Ltd
Barlow-Whitney Ltd
Cuthbert Ltd, Ralph
Gallenkamp & Co Ltd, A.
General Electric Co Ltd, The
Griffin & George Ltd
Harris (Birmingham) Ltd, F. & R. M.
Laboratory Apparatus & Glass Blowing Co
Leland Instruments Ltd
Marine & Industrial Plastics Ltd
Royce Electric Furnaces Ltd
Scientific Furnishings Ltd
Shandon Scientific Co Ltd
Spembly Ltd
Towers & Co Ltd, J. W.

OVENS—VACUUM
★ Circle *No 769* on reply card
AEW Ltd
Baird & Tatlock (London) Ltd
Barlow-Whitney Ltd
Blundell & Crompton Ltd
Butterfield Ltd, W. P.
Edwards High Vacuum Ltd
Foster Yates & Shaw Ltd
Gallenkamp & Co Ltd, A.
Griffin & George Ltd
Leybold Vacuum Sales Ltd
NGN Electrical Ltd
Pulsometer Engineering Co Ltd, The
Spembly Ltd
Towers & Co Ltd, J. W.
Vacuum Industrial Applications Ltd
Walker Ltd, C. & W.
Western Detail Mfrs Ltd

PANELS—INSTRUMENT
★ Circle *No 770* on reply card
Accurate Recording Instrument Co Ltd
Allied Electronics Ltd
Appleby & Ireland Ltd
Armstrong Whitworth Aircraft Ltd, Sir W. G.
Ayling Nuclear Equipment Co
Brown & Co Ltd, F. G.
Constructors John Brown Ltd
Elliott Bros (London) Ltd
Ericsson Telephones Ltd
Evershed & Vignoles Ltd
General Electric Co Ltd, The
General Radiological Ltd
Gordon & Co Ltd, James
Hall & Co Ltd, Matthew
Hendrey Relays Ltd
Honeywell-Brown Ltd
Hutcheon Duthie & Son Ltd, R.
Integra, Leeds & Northrup Ltd
Ionic Instruments (London) Ltd
IV Pressure Controllers Ltd
KDG Instruments Ltd
Kent Ltd, George
Kelvin & Hughes Ltd
Laboratory Apparatus & Glass Blowing Co
Laurence, Scott & Electromotors Ltd
Leland Instruments Ltd
Lock & Co Ltd, A. M.
Londex Ltd
Metal Gravure Co Ltd, The
New Western (Engineering) Ltd
Permali Ltd
Reyrolle & Co Ltd, A.
Ryder & Co (Manchester) Ltd, Thomas
Salford Electrical Instruments Ltd
Southborough (Weybridge) Ltd
Spembly Ltd
Stabilag Co Ltd, The
Sunvic Controls Ltd
Taylor Controls Ltd
Taylor-Short & Mason Ltd
Thermocontrol Installations Co Ltd
Thompson Instrument Co Ltd, John
West Instruments Ltd
Western Detail Mfrs Ltd

PERISCOPES
★ Circle *No 771* on reply card
Allen & Co, P. W.
Avimo Ltd
Foster Instrument Co Ltd
Optical Works Ltd
Ross Ensign Ltd
Spembly Ltd

PHOTOCELLS & DEVICES
★ Circle *No 772* on reply card
Airmec Ltd
Allied Electronics Ltd

PHOTOCELLS & DEVICES—*continued*
Baldwin Instrument Co Ltd
British Thomson-Houston Co Ltd, The
Counting Instruments Ltd
Dowty Nucleonics Ltd
Elcontrol Ltd
EMI Electronics Ltd
Evans Electroselenium Ltd
General Electric Co Ltd, The
Hilger & Watts Ltd
Holiday & Hemmerdinger Ltd
Hutcheon Duthie & Son Ltd, R.
Lancashire Dynamo Electronic Products Ltd
Leland Instruments Ltd
Lock & Co Ltd, A. M.
Londex Ltd
Megatron Ltd
Metropolitan-Vickers Electrical Co Ltd
Mullard Ltd
Radiovisor Parent Ltd
Rank Cintel Ltd
Research & Control Instruments Ltd
Sangamo Weston Ltd
Siemens Edison Swan Ltd
Spembly Ltd
Standard Telephones & Cables Ltd
Stonebridge Electrical Co Ltd

PHOTOGRAPHIC MATERIALS
★ Circle *No 773* on reply card
General Chemical & Pharmaceutical Co Ltd, The
Ilford Ltd
Kodak Ltd
Mason & Sons Ltd, E. N.

PHOTOMULTIPLIER TUBES
★ Circle *No 774* on reply card
B. & K. Laboratories Ltd
EMI Electronics Ltd
ERD Engineering Co Ltd
Isotope Developments Ltd
Leland Instruments Ltd
Mullard Ltd
Rank Cintel Ltd
Reid Manufacturing Co Ltd, A.
Siemens Edison Swan Ltd
20th Century Electronics Ltd

PIRANI GAUGES
★ Circle *No 775* on reply card
Edwards High Vacuum Ltd
Griffin & George Ltd
Leybold Vacuum Sales Ltd
Lock & Co Ltd, A. M.
NGN Electrical Ltd
Newton Victor Ltd
Vacuum Industrial Applications Ltd

POLAROGRAPHS
★ Circle *No 776* on reply card
Cambridge Instrument Co Ltd
Cuthbert Ltd, Ralph
Evershed & Vignoles Ltd
Integra, Leeds & Northrup Ltd
Lock & Co Ltd, A. M.
Lyons Ltd, Claude (agents for General Radio Co USA)
Mervyn Instruments
Southern Instruments (Computer Division)

POTENTIOMETERS
★ Circle *No 777* on reply card
Baird & Tatlock (London) Ltd
B. & K. Laboratories Ltd
Cambridge Instrument Co Ltd
Cuthbert Ltd, Ralph
Doran Instrument Co Ltd
Fox Ltd, P. X. (precision and power)
Geipel Ltd, William
General Electric Co Ltd, The
Griffin & George Ltd
Holiday & Hemmerdinger Ltd
Honeywell-Brown Ltd
Integra, Leeds & Northrup Ltd
Isenthal & Co Ltd
Kent Ltd, George
Lock & Co Ltd, A. M.
Morganite Resistors Ltd
Plessey Co Ltd, The
Salford Electrical Instruments Ltd
Siemens Edison Swan Ltd
Shandon Scientific Co Ltd
Tinsley & Co Ltd, H.

POWER UNITS—e.h.t.
★ Circle *No 778* on reply card
Armstrong Whitworth Aircraft Ltd, Sir W. G.
Cawkell Research & Electronics Ltd
Dynatron Radio Ltd
Ekco Electronics Ltd
Electric Construction Co Ltd, The
EMI Electronics Ltd
Ericsson Telephones Ltd
Falk & Co Ltd, M.
General Radiological Ltd
Hivolt Ltd
Holiday & Hemmerdinger Ltd
Isotope Developments Ltd
Labgear Ltd
Lancashire Dynamo Electronic Products Ltd
Leland Instruments Ltd
Livingston Laboratories Ltd
Lock & Co Ltd, A. M.
McKellen Automation Ltd
Metropolitan-Vickers Electrical Co Ltd
Panax Equipment Ltd
Plessey Nucleonics Ltd
Philips Electrical Ltd
Rank Cintel Ltd
Shandon Scientific Co Ltd
Southern Instruments (Computer Division)
Sunvic Controls Ltd

POWER UNITS—h.t.
★ Circle *No 779* on reply card
Allied Electronics Ltd
Armstrong Whitworth Aircraft Ltd, Sir W. G.
Boulton Paul Aircraft Ltd
Cawkell Research & Electronics Ltd
Ekco Electronics Ltd
Electric Construction Co Ltd, The
Elliott Brothers (London) Ltd

POWER UNITS—h.t.—*continued*
EMI Electronics Ltd
Ericsson Telephones Ltd
General Radiological Ltd
Harvey Electronics Ltd
Isotope Developments Ltd
Labgear Ltd
Lancashire Dynamo Electronic Products Ltd
Leland Instruments Ltd
Livingston Laboratories Ltd
Lock & Co Ltd, A. M.
McKellen Automation Ltd
Metropolitan-Vickers Electrical Co Ltd
Panax Equipment Ltd
Plessey Nucleonics Ltd
Pringle & Sons (London) Ltd, Robert
Salford Electrical Instruments Ltd
Shandon Scientific Co Ltd
Solartron Electronic Group Ltd
Southern Instruments (Computer Division)

POWER UNITS—l.t.
★ Circle *No 780* on reply card
Armstrong Whitworth Aircraft Ltd, Sir W. G.
Austinlite Ltd
Cawkell Research & Electronics Ltd
Electric Construction Co Ltd, The
General Radiological Ltd
Isotope Developments Ltd
Joyce, Loebl & Co Ltd
Labgear (Cambridge) Ltd
Lancashire Dynamo Electronic Products Ltd
Leland Instruments Ltd
Livingston Laboratories Ltd
McKellen Automation Ltd
Metropolitan-Vickers Electrical Co Ltd
Plessey Nucleonics Ltd
Pringle & Sons (London) Ltd, Robert
Rank Cintel Ltd
Salford Electrical Instruments Ltd
Servomex Controls Ltd
Shandon Scientific Co Ltd
Solartron Electronic Group Ltd
Standard Telephones & Cables Ltd

POWER UNITS—STABILIZED
★ Circle *No 781* on reply card
Airmec Ltd
Allied Electronics Ltd
Armstrong Whitworth Aircraft Ltd, Sir W. G.
Austinlite Ltd
Boulton Paul Aircraft Ltd
Cawkell Research & Electronics Ltd
Doran Instrument Co Ltd
Dynatron Radio Ltd
Elliott Brothers (London) Ltd
Ericsson Telephones Ltd
Falk & Co Ltd, M.
Furzehill Laboratories Ltd
Gallenkamp & Co Ltd, A.
General Radiological Ltd
Harvey Electronics Ltd
Hilger & Watts Ltd
Hirst Electronics Ltd
Hivolt Ltd
Isotope Developments Ltd
Joyce, Loebl & Co Ltd
Labgear Ltd
Lancashire Dynamo Electronic Products Ltd
Leland Instruments Ltd
Livingston Laboratories Ltd
Lyons Ltd, Claude
McKellen Automation Ltd
Metropolitan-Vickers Electrical Co Ltd
Panax Equipment Ltd
Plessey Nucleonics Ltd
Pringle & Sons (London) Ltd, Robert
Racal Engineering Ltd
Rank Cintel Ltd
Savage & Parsons Ltd
Servomex Controls Ltd
Shandon Scientific Co Ltd
Siemens Edison Swan Ltd
Solartron Electronic Group Ltd
Standard Telephones & Cables Ltd
Tinsley & Co Ltd, H.

PRE-AMPLIFIERS
★ Circle *No 782* on reply card
Armstrong Whitworth Aircraft Ltd, Sir W. G.
Cawkell Research & Electronics Ltd
Cossor Instruments Ltd
Ekco Electronics Ltd
EMI Electronics Ltd
Ericsson Telephones Ltd
Glass Developments, Ltd
Holiday & Hemmerdinger Ltd
Joyce, Loebl & Co Ltd
Kelvin & Hughes (Industrial) Ltd
Labgear Ltd
Livingston Laboratories Ltd
Lock & Co Ltd, A. M.
Mullard Ltd
Nagard Ltd
Plessey Nucleonics Ltd
Rank Cintel Ltd
Research & Control Instruments Ltd
Siemens Edison Swan Ltd
Sunvic Controls Ltd

PRECIOUS METALS
★ Circle *No 783* on reply card
Baker Platinum Div, Engelhard Industries Ltd
General Chemical & Pharmaceutical Co Ltd, The
Johnson, Matthey & Co Ltd
Laboratory Apparatus & Glass Blowing Co
Mond Nickel Co Ltd, The
Sheffield Smelting Co Ltd, The

PRESCALERS
★ Circle *No 784* on reply card
Isotope Developments Ltd
Labgear Ltd
Lock & Co Ltd, A. M.
Panax Equipment Ltd
Sunvic Controls Ltd

PRESSURESTATS
★ Circle *No 785* on reply card
Accurate Recording Instrument Co, The
Alexander Controls Ltd
Honeywell-Brown Ltd

PRESSURESTATS—*continued*
Leybold Vacuum Sales Ltd
Londex Ltd
Monitor Patent Safety Devices Ltd
Nash & Thompson Ltd
Teddington Industrial Equipment Ltd
Thermocontrol Installations Co Ltd

PROBE UNITS—NUCLEONIC
★ Circle *No 786* on reply card
Dynatron Radio Ltd
Ekco Electronics Ltd
Ericsson Telephones Ltd
Fleming Radio (Development) Ltd
General Radiological Ltd
Isotope Developments Ltd
Kelvin & Hughes (Industrial) Ltd
Labgear Ltd
Panax Equipment Ltd
Plessey Nucleonics Ltd
Research & Control Instruments Ltd

PROBE QUENCH UNITS
★ Circle *No 787* on reply card
Burndept Ltd
Dynatron Radio Ltd
Ekco Electronics Ltd
Ericsson Telephones Ltd
General Radiological Ltd
Isotope Developments Ltd
Labgear Ltd

PUMPS—COMBINED VACUUM & PRESSURE
★ Circle *No 788* on reply card
Alley & Maclellan Ltd
Baird & Tatlock (London) Ltd
Ben Patents Ltd
Broom & Wade Ltd
Clarke, Chapman & Co Ltd
Cuthbert Ltd, Ralph
Edwards High Vacuum Ltd
Gallenkamp & Co Ltd, A.
Griffin & George Ltd
Lacy-Hulbert & Co Ltd
Leybold Vacuum Sales Ltd
Mono Pumps Ltd
NGN Electrical Ltd
Northey Rotary Compressors Ltd
Pulsometer Engineering Co Ltd, The
Reavell & Co Ltd
Vacuum Industrial Applications Ltd
Wade Engineering Ltd
Western Detail Mfrs Ltd
Whittaker Hall & Co (1929) Ltd

PUMPS—GAS BALLAST & BOOSTER
★ Circle *No 789* on reply card
ECD Ltd
Edwards High Vacuum Ltd
Fleischmann (London) Ltd
Holland Engineering Co Ltd, B. A.
Leybold Vacuum Sales Ltd
Metropolitan-Vickers Electrical Co Ltd
Northey Rotary Compressors Ltd
Pulsometer Engineering Co Ltd, The
Reavell & Co Ltd
Sigmund Pumps Ltd
Vacuum Industrial Applications Ltd
Western Detail Mfrs Ltd
Whittaker Hall & Co (1929) Ltd

PUMPS—HIGH VACUUM, ION GETTER
★ Circle *No 790* on reply card
Edwards High Vacuum Ltd
Leybold Vacuum Sales Ltd
Fleischmann (London) Ltd
Pulsometer Engineering Co Ltd, The
Vacuum Industrial Applications Ltd
Western Detail Mfrs Ltd

PUMPS—HIGH VACUUM, MERCURY DIFFUSION
★ Circle *No 791* on reply card
Cuthbert Ltd, Ralph
Edwards High Vacuum Ltd
Fleischmann (London) Ltd
Glass Developments Ltd
Griffin & George Ltd
Leybold Vacuum Sales Ltd
Metropolitan-Vickers Electrical Co Ltd
NGN Electrical Ltd
Pulsometer Engineering Co Ltd, The
Springham & Co, G. H.
Thermal Syndicate Ltd, The
Towers & Co Ltd, J. W.
Western Detail Mfrs Ltd

PUMPS—HIGH VACUUM, OIL DIFFUSION
★ Circle *No 792* on reply card
Edwards High Vacuum Ltd
Fleischmann (London) Ltd
Glass Developments Ltd
Griffin & George Ltd
Leland Instruments Ltd
Leybold Vacuum Sales Ltd
Metropolitan-Vickers Electrical Co Ltd
NGN Electrical Ltd
Pulsometer Engineering Co Ltd, The
Vacuum Industrial Applications Ltd
Western Detail Mfrs Ltd

PUMPS—VACUUM, ROTARY
★ Circle *No 793* on reply card
Belliss & Morcom Ltd
Ben Patents Ltd
Edwards High Vacuum Ltd
Fleischmann (London) Ltd
Gallenkamp & Co Ltd, A.
Griffin & George Ltd
Holland Engineering Co Ltd, B. A.
Lacy-Hulbert & Co Ltd
Leybold Vacuum Sales Ltd
Metropolitan-Vickers Electrical Co Ltd
Mirrlees (Engineers) Ltd
Mono Pumps Ltd
NGN Electrical Ltd
Northey Rotary Compressors Ltd
Pulsometer Engineering Co Ltd, The
Reavell & Co Ltd
Towers & Co Ltd, J. W.
Vacuum Industrial Applications Ltd
Wade Engineering Ltd

PUMPS—VACUUM ROTARY—*continued*
Western Detail Mfrs Ltd
Whittaker Hall & Co (1929) Ltd
Williams & James (Engineers) Ltd
Worthington-Simpson Ltd

PUMPS—WATER JET
Edwards High Vacuum Ltd
Gallenkamp & Co Ltd, A.
Griffin & George Ltd
Leybold Vacuum Sales Ltd
Mono Pumps Ltd
QVF Ltd
Sealed Motor Construction Co Ltd
Towers & Co Ltd, J. W.
Western Detail Mfrs Ltd
★ Circle *No 794* on reply card

PYROMETERS—OPTICAL
★ Circle *No 795* on reply card
AEW Ltd
Baird & Tatlock (London) Ltd
Cambridge Instrument Co Ltd
Elliott Bros (London) Ltd
Evershed & Vignoles Ltd
Foster Instrument Co Ltd
Griffin & George Ltd

PYROMETERS—PHOTOELECTRIC
★ Circle *No 796* on reply card
AEW Ltd
Cambridge Instrument Co Ltd
Elcontrol Ltd
Foster Instrument Co Ltd
Kent Ltd, George
Lancashire Dynamo Electronic Products Ltd
Lock & Co Ltd, A. M.
West Instruments Ltd

PYROMETERS—POTENTIOMETRIC
★ Circle *No 797* on reply card
AEW Ltd
Cambridge Instrument Co Ltd
Elliott Brothers (London) Ltd
Foster Instrument Co Ltd
Honeywell-Brown Ltd
Integra, Leeds & Northrup Ltd
Kent Ltd, George
Negretti & Zambra Ltd
Shandon Scientific Co Ltd
Thermocontrol Installations Co Ltd
West Instruments Ltd
White Electrical Instrument Co Ltd

PYROMETERS—RADIATION
★ Circle *No 798* on reply card
AEW Ltd
Baird & Tatlock (London) Ltd
British Thomson-Houston Co Ltd, The
Cambridge Instrument Co Ltd
Elliott Bros (London) Ltd
Evershed & Vignoles Ltd
Foster Instrument Co Ltd
Honeywell-Brown Ltd
Kent Ltd, George
Lancashire Dynamo Electronic Products Ltd

PYROMETERS—RESISTANCE
★ Circle *No 799* on reply card
AEW Ltd
Cambridge Instrument Co Ltd
CNS Instruments Ltd
Cuthbert Ltd, Ralph
Elliott Bros (London) Ltd
Fielden Electronics Ltd
Foster Instrument Co Ltd
Honeywell-Brown Ltd
Integra, Leeds & Northrup Ltd
KDG Instruments Ltd
Kelvin & Hughes (Industrial) Ltd
Kent Ltd, George
Lancashire Dynamo Electronic Products Ltd
Negretti & Zambra Ltd
Sangamo Weston Ltd
Thermocontrol Installations Co Ltd
West Instruments Ltd
White Electrical Instrument Co Ltd

PYROMETERS—THERMO-ELECTRIC
★ Circle *No 800* on reply card
AEW Ltd
Cambridge Instrument Co Ltd
Cuthbert Ltd, Ralph
Electrothermal Engineering Ltd
Elliott Bros (London) Ltd
Evershed & Vignoles Ltd
Foster Instrument Co Ltd
Griffin & George Ltd
Honeywell-Brown Ltd
Kelvin & Hughes Ltd
Kent Ltd, George
Measuring Instruments (Pullin) Ltd
Negretti & Zambra Ltd
Spembly Ltd
Thermocontrol Installations Co Ltd
White Electrical Instrument Co Ltd

QUARTZ APPARATUS
★ Circle *No 801* on reply card
Fleischmann (London) Ltd
General Radiological Ltd
Glass Developments Ltd
Hanovia Lamps
Laboratory Apparatus & Glass Blowing Co
Nash & Thompson Ltd
Salford Electrical Instruments Ltd
Stabilag Co Ltd, The
Thermal Syndicate Ltd, The
Towers & Co Ltd, J. W.

RACKS—CABINET
★ Circle *No 802* on reply card
Armstrong Whitworth Aircraft Ltd, Sir W. G.
Brown & Co Ltd, E. G.
Dynatron Radio Ltd
Ekco Electronics Ltd
Labgear Ltd
Rediweld Ltd
Southborough (Weybridge) Ltd

RADIOGRAPHY APPARATUS—X-RAY
★ Circle *No 803* on reply card
Andrews Ltd, Cuthbert

RADIOGRAPHY APPARATUS—*continued*
Ashmore, Benson, Pease & Co
Falk & Co Ltd, M.
Gamma-Rays Ltd
General Electric Co Ltd, The
General Radiological Ltd
Ilford Ltd
Kodak Ltd
Metropolitan-Vickers Electrical Co Ltd
Mullard Ltd
Newton Victor Ltd
Nuclear Engineering Ltd
Research & Control Instruments Ltd
Solus-Schall Ltd
Welding Supervision Ltd

RADIOGRAPHY SERVICES (*See Section 1*)

RADON EMANATION PLANT
★ Circle *No 804* on reply card
Edwards High Vacuum Ltd

RATEMETERS—FIELD
★ Circle *No 805* on reply card
Elliott Brothers (London) Ltd
Ericsson Telephones Ltd
Falk & Co Ltd, M.
Fleming Radio (Developments) Ltd
General Radiological Ltd
Isotope Developments Ltd
Labgear Ltd
Nuclear Enterprises (GB) Ltd
Nucleonic & Radiological Developments Ltd
Panax Equipment Ltd
Plessey Nucleonics Ltd
Research & Control Instruments Ltd

RATEMETERS—LABORATORY
★ Circle *No 806* on reply card
Burndept Ltd
Cuthbert Ltd, Ralph
Ericsson Telephones Ltd
Ekco Electronics Ltd
Falk & Co Ltd, M.
Fleming Radio (Developments) Ltd
General Radiological Ltd
Isotope Developments Ltd
Labgear Ltd
Leland Instruments Ltd
Lock & Co Ltd, A. M.
Nuclear Enterprises (GB) Ltd
Panax Equipment Ltd
Plessey Nucleonics Ltd
Research & Control Instruments Ltd

RATEMETERS—PORTABLE
★ Circle *No 807* on reply card
Ericsson Telephones Ltd
Falk & Co Ltd, M.
Fleming Radio (Developments) Ltd
General Radiological Ltd
Isotope Developments Ltd
Labgear Ltd
Nuclear Enterprises (GB) Ltd
Nucleonic & Radiological Developments Ltd
Panax Equipment Ltd
Plessey Nucleonics Ltd
Research & Control Instruments Ltd

RATEMETERS—RECORDING
★ Circle *No 808* on reply card
Falk & Co Ltd, M.
Isotope Developments Ltd
Kent Ltd, George
Labgear Ltd
Leland Instruments Ltd
Panax Equipment Ltd

REACTOR CONTROL SYSTEMS (*see Sec. 1*)

REACTORS—NUCLEAR RESEARCH
★ Circle *No 809* on reply card
AEI—John Thompson Nuclear Energy Co Ltd
Hawker Siddeley Nuclear Power Co Ltd (all types)
Head Wrightson Processes Ltd
Research & Control Instruments Ltd

RECORDERS—ANNULAR CHART
★ Circle *No 810* on reply card
Accurate Recording Instrument Co, The
Appleby & Ireland Ltd
British Rototherm Co Ltd, The
Cambridge Instrument Co Ltd
Elliott Brothers (London) Ltd
Evershed & Vignoles Ltd
Fielden Electronics Ltd
Foxboro-Yoxall Ltd
Glass Developments Ltd
Gordon & Co Ltd, James
Hendrey Relays Ltd
Honeywell-Brown Ltd
Isotope Developments Ltd
Kelvin & Hughes Ltd
Kent Ltd, George
Lancashire Dynamo Electronic Products Ltd
McKellen Automation Ltd
Nash & Thompson Ltd
Record Electrical Co Ltd, The
Research & Control Instruments Ltd
Savage & Parsons Ltd
Southern Instruments, Computer Division
Sunvic Controls Ltd
Taylor-Short & Mason Ltd
Thermocontrol Installations Co Ltd

RECORDERS—POTENTIOMETRIC, STRIP CHART
★ Circle *No 811* on reply card
B. & K. Laboratories Ltd
Cambridge Instrument Co Ltd
Elliott Bros (London) Ltd
Evershed & Vignoles Ltd
Foster Instrument Co Ltd
Foxboro Yoxall Ltd
Honeywell-Brown Ltd
Integra, Leeds & Northrup Ltd
Kent Ltd, George
Lancashire Dynamo Electronic Products Ltd
Livingston Laboratories Ltd
McKellen Automation Ltd
Negretti & Zambra Ltd
Pye & Co Ltd, W. G.
Research & Control Instruments Ltd
Sangamo Weston Ltd

RECORDERS—POTENTIOMETER, STRIP CHART—*continued*
Stonebridge Electrical Co Ltd
Sunvic Controls Ltd
Thermocontrol Installations Co Ltd
West Instruments Ltd

RECORDERS—STRIP CHART, MULTI-POINT
★ Circle *No 812* on reply card
B. & K. Laboratories Ltd
Cambridge Instrument Co Ltd
Elliott Bros (London) Ltd
Evershed & Vignoles Ltd
Foster Instrument Co Ltd
Hendrey Relays Ltd
Honeywell-Brown Ltd
Integra, Leeds & Northrup Ltd
Kelvin & Hughes (Industrial) Ltd
Kent Ltd, George
Leland Instruments Ltd
Livingston Laboratories Ltd
McKellen Automation Ltd
Negretti & Zambra Ltd
Research & Control Instruments Ltd
Siemens Edison Swan Ltd
Sigma Instrument Co Ltd
Smiths Industrial Instruments Ltd
Sunvic Controls Ltd

RECORDERS—TIME
★ Circle *No 813* on reply card
Electronic Instruments Ltd
Integra, Leeds & Northrup Ltd
Kent Ltd, George
McKellen Automation Ltd
Measuring Instruments (Pullin) Ltd
Research & Control Instruments Ltd
Servis Recorders Ltd

RECORDERS—VACUUM
★ Circle *No 814* on reply card
Accurate Recording Instrument Co Ltd
Appleby & Ireland Ltd
British Rototherm Co Ltd, The
Cambridge Instrument Co Ltd
Edwards High Vacuum Ltd
Evershed & Vignoles Ltd
Fleischmann (London) Ltd
Honeywell-Brown Ltd
Kent Ltd, George
Leybold Vacuum Sales Ltd
Negretti & Zambra Ltd
NGN Electrical Ltd
Vacuum Industrial Applications Ltd

RECTIFIERS—DRY PLATE
★ Circle *No 815* on reply card
British Thomson-Houston Co Ltd, The
Electric Construction Co Ltd, The
General Electric Co Ltd, The
Hackbridge & Hewittic Electric Co Ltd
Hirst Electronic Ltd
Holiday & Hemmerdinger Ltd
Research & Control Instruments Ltd
Salford Electrical Instruments Ltd
Standard Telephones & Cables Ltd
Texas Instruments Ltd
Westinghouse Brake & Signal Co Ltd

RECTIFIERS—MERCURY ARC
★ Circle *No 816* on reply card
British Thomson-Houston Co Ltd, The
Electric Construction Co Ltd, The
English Electric Co Ltd, The
General Electric Co Ltd, The
Hackbridge & Hewittic Electric Co Ltd
Hirst Electronic Ltd
Newton Victor Ltd
Research & Control Instruments Ltd
Texas Instruments Ltd

RECTIFIERS—THERMIONIC
★ Circle *No 817* on reply card
British Thomson-Houston Co Ltd, The
Ferranti Ltd
General Electric Co Ltd, The
General Radiological Ltd
Hirst Electronic Ltd
Holiday & Hemmerdinger Ltd
Lancashire Dynamo Electronic Products Ltd
Mullard Ltd
Research & Control Instruments Ltd
Standard Telephones & Cables Ltd
Texas Instruments Ltd

RELAYS—a.c.
★ Circle *No 818* on reply card
ASEA Electric Ltd
Austinlite Ltd
British Thomson-Houston Co Ltd
Chamberlain & Hookham Ltd
Cuthbert Ltd, Ralph
Donovan Electrical Co Ltd
Electric Construction Co Ltd, The
Electro Methods Ltd
Elliott Brothers (London) Ltd
English Electric Co Ltd, The
Ericsson Telephones Ltd
Ferranti Ltd
Geipel Ltd, William
General Electric Co Ltd, The
Hendrey Relays Ltd
Isenthal & Co Ltd
Kent Ltd, George
Klöckner Moeller England Ltd
Lancashire Dynamo Electronic Products Ltd
Lock & Co Ltd, A. M.
Londex Ltd
Magnetic Devices Ltd
Measuring Instruments (Pullin) Ltd
Metropolitan-Vickers Electrical Co Ltd
Pye Ltd
Record Electrical Co Ltd, The
Reyrolle & Co Ltd, A.
Salford Electrical Instruments Ltd
Sangamo Weston Ltd
Simmonds Ltd, L. E.
Smiths Industrial Instruments Ltd
Standard Telephones & Cables Ltd
Stone Chance Ltd
Sunvic Controls Ltd
Thermocontrol Installations Co Ltd
West Instruments Ltd
White Electrical Instrument Co Ltd

RELAYS—d.c.
★ Circle *No 819* on reply card
ASEA Electric Ltd
Austinlite Ltd
British Thomson-Houston Co Ltd, The
Chamberlain & Hookham Ltd
Cuthbert Ltd, Ralph
Donovan Electrical Co Ltd
Electro Methods Ltd
Electronic Construction Co Ltd, The
Elliott Brothers (London) Ltd
English Electric Co Ltd, The
Ericsson Telephones Ltd
Ferranti Ltd
Geipel Ltd, William
General Electric Co Ltd, The
Hendrey Relays Ltd
Isenthal & Co Ltd
Kent Ltd, George
Lancashire Dynamo Electronic Products Ltd
Leland Instruments Ltd
Londex Ltd
Magnetic Devices Ltd
Measuring Instruments (Pullin) Ltd
Metropolitan-Vickers Electrical Co Ltd
Plessey Nucleonics Ltd
Pullin & Co Ltd, R. B.
Pye Ltd
Record Electrical Co Ltd, The
Reyrolle & Co Ltd, A.
Salford Electrical Instruments Ltd
Sangamo Weston Ltd
Simmonds Ltd, L. E.
Smiths Industrial Instruments Ltd
Standard Telephones & Cables Ltd
Stone Chance Ltd
Sunvic Controls Ltd
West Instruments Ltd
White Electrical Instrument Co Ltd

RELAYS—ELECTRONIC
★ Circle *No 820* on reply card
Allied Electronics Ltd
Austinlite Ltd
British Thomson-Houston Co Ltd, The
Elcontrol Ltd
Electric Construction Co Ltd, The
Elliott Brothers (London) Ltd
Fielden Electronics Ltd
General Electric Co Ltd, The
Kent Ltd, George
Labgear Ltd
Lancashire Dynamo Electronic Products Ltd
Lock & Co Ltd, A. M.
Londex Ltd
Magnetic Devices Ltd
Metropolitan-Vickers Electrical Co Ltd
Simmonds Ltd, L. E.
Standard Telephones & Cables Ltd
Sunvic Controls Ltd
Thermocontrol Installations Co Ltd

RELAYS—PHOTO-ELECTRIC
★ Circle *No 821* on reply card
Allied Electronics Ltd
Airmec Ltd
British Thomson-Houston Co Ltd, The
Cawkell, A. E.
Dowty Nucleonics Ltd
Elcontrol Ltd
General Electric Co Ltd, The
Lancashire Dynamo Electronic Products Ltd
Lock & Co Ltd, A. M.
Londex Ltd
Metropolitan-Vickers Electrical Co Ltd
Standard Telephones & Cables Ltd
Stonebridge Electrical Co Ltd

RELAYS—TIME DELAY
★ Circle *No 822* on reply card
Allied Electronics Ltd
ASEA Electric Ltd
Austinlite Ltd
B. & K. Laboratories Ltd
Boulton Paul Aircraft Ltd
British Thomson-Houston Co Ltd, The
Chamberlain & Hookham Ltd
Cuthbert Ltd, Ralph
Elcontrol Ltd
Electrothermal Engineering Ltd
Electro Methods Ltd
English Electric Co Ltd, The
Geipel Ltd, William
General Electric Co Ltd, The
Hendrey Relays Ltd
Hirst Electronic Ltd
Isenthal & Co Ltd
Lancashire Dynamo Electronic Products Ltd
Lock & Co Ltd, A. M.
Londex Ltd
Metropolitan-Vickers Electrical Co Ltd
Nagard Ltd
Research & Control Instruments Ltd
Reyrolle & Co Ltd, A.
Standard Telephones & Cables Ltd
Sunvic Controls Ltd
Thermocontrol Installations Co Ltd

REMOTE CONTROL EQUIPMENT
★ Circle *No 823* on reply card
Appleby & Ireland Ltd
Ardleigh Engineering Ltd
Arens Controls Ltd
Automatic Telephone & Electric Co Ltd
Bell Precision Engineering Co Ltd
British Northern Electrical Appliances Ltd
British Thomson-Houston Co Ltd, The
Burndept Ltd
Chatwood-Milner Ltd
Compoflex Co Ltd
Electro-Hydraulics Ltd
Elcontrol Ltd
Electric Construction Co Ltd, The
Elliott Bros (London) Ltd
English Electric Co Ltd, The
Evans & Son (Portsmouth) Ltd, J.
Evershed & Vignoles Ltd
Exactor Ltd
Geipel Ltd, William
General Electric Co Ltd, The
Globe Pneumatic Co Ltd
Gordon & Co Ltd, James

REMOTE CONTROL EQUIPMENT—*continued*
Hall & Co Ltd, Matthew
Hendrey Relays Ltd
Hobson Ltd, H. M.
Integra, Leeds & Northrup Ltd
Kent Ltd, George
Ketay Ltd
Lancashire Dynamo Electronic Products Ltd
Lincoln Electric Co Ltd
Lock & Co Ltd, A. M.
Londex Ltd
Marine & Industrial Plastics Ltd
Measuring Instruments (Pullin) Ltd
Metropolitan-Vickers Electrical Co Ltd, The
Mollart Engineering Co Ltd, The
Morris Ltd, B. O.
Muirhead & Co Ltd
Negretti & Zambra Ltd
Nuclear Engineering Ltd
Palatine Tool & Engineering Co (Surbiton) Ltd
Parkinson & Cowan Ltd
Plessey Nucleonics Ltd
Pye Ltd
Reyrolle & Co Ltd, A.
Salford Electrical Instruments Ltd
Savage & Parsons Ltd
Sealey Engineering Co Ltd
Siemens Edison Swan Ltd
Spembly Ltd
Standard Telephones & Cables Ltd
Taylor Controls Ltd
Teddington Industrial Equipment Ltd
Teleflex Products Ltd
Thermocontrol Installations Co Ltd
Vaughan Crane Co Ltd, The
Walker Ltd, C. & W.
Western Detail Mfrs Ltd
Weyers Bros Ltd

SAMPLE CHANGERS
★ Circle *No 824* on reply card
B. & K. Laboratories Ltd
Labgear Ltd
Research & Control Instruments Ltd
Western Detail Mfrs Ltd

SAMPLE HOLDERS
★ Circle *No 825* on reply card
B. & K. Laboratories Ltd
Falk & Co Ltd, M.
Labgear Ltd
Western Detail Mfrs Ltd

SCALERS
★ Circle *No 826* on reply card
Allied Electronics Ltd
B. & K. Laboratories Ltd
Dynatron Radio Ltd
Ekco Electronics Ltd
Elliott Brothers (London) Ltd
Ericsson Telephones Ltd
Falk & Co Ltd, M.
General Radiological Ltd
Isotope Developments Ltd
Labgear Ltd
Leland Instruments Ltd
Livingston Laboratories Ltd
Lock & Co Ltd, A. M.
Nucleonic & Radiological Developments
Panax Equipment Ltd
Philips Electrical Ltd
Pye Ltd
Rank Cintel Ltd
Sunvic Controls Ltd

SCINTILLATORS—INORGANIC
★ Circle *No 827* on reply card
Ekco Electronics Ltd
Isotope Developments Ltd
Nash & Thompson Ltd
Nuclear Enterprises (GB) Ltd
Research & Control Instruments Ltd

SCINTILLATORS—LIQUID
★ Circle *No 828* on reply card
Ekco Electronics Ltd
Isotope Developments Ltd
Lock & Co Ltd, A. M.
Nash & Thompson Ltd
Nuclear Enterprises (GB) Ltd

SCINTILLATORS—ORGANIC
★ Circle *No 829* on reply card
Hilger & Watts Ltd
Nash & Thompson Ltd
Nuclear Enterprises (GB) Ltd

SCINTILLATORS—PLASTIC
★ Circle *No 830* on reply card
Isotope Developments Ltd
Lock & Co Ltd, A. M.
Nash & Thompson Ltd
Nuclear Enterprises (GB) Ltd

SERVO MECHANISMS
★ Circle *No 831* on reply card
Appleby & Ireland Ltd
Ardleigh Engineering Ltd
British Thomson-Houston Co Ltd, The
Dowty Nucleonics Ltd
Electro-Hydraulics Ltd
Elliott Bros (London) Ltd
English Electric Co Ltd, The
Evershed & Vignoles Ltd
Ferranti Ltd
General Electric Co Ltd, The
Glass Developments Ltd
Gordon & Co Ltd, James
Harvey Electronics Ltd
Hawker Siddeley Nuclear Power Co Ltd
Hobson Ltd, H. M.
Isenthal & Co Ltd
Kent Ltd, George
Ketay Ltd
Lancashire Dynamo Electronic Products Ltd
Muirhead & Co Ltd
Parkinson & Cowan Ltd
Pye Ltd
Sealey Engineering Co Ltd
Servomex Controls Ltd
Short Bros & Harland Ltd
Solartron Electronic Group Ltd

SERVO MECHANISMS—*continued*
Thompson Ordnance Co, John
Western Detail Mfrs Ltd
Weyers Bros Ltd
Winston Electronics Ltd

SIEVES—BRITISH STANDARD
★ Circle *No 832* on reply card
Baird & Tatlock (London) Ltd
Cornwall Mills Ltd
Cuthbert Ltd, Ralph
Endecotts (Filters) Ltd
Gallenkamp & Co Ltd, A.
Griffin & George Ltd
KC Productions Ltd
Laboratory Apparatus & Glass Blowing Co
Pascall Engineering Co Ltd, The
Springham & Co, G. H.
Towers & Co Ltd, J. W.

SILICA GEL DRIERS
★ Circle *No 833* on reply card
Burnett & Lewis Ltd
Gallenkamp & Co Ltd, A.
Incandescent Heat Co Ltd
Kestner Evaporator & Engineering Co
Magnetic Equipment Co Ltd, The
QVF Ltd
Service Electric Co Ltd
Silica Gel Ltd
Thermo-Plastics Ltd
Williams & James (Engineers) Ltd

SIMULATORS—REACTOR
★ Circle *No 834* on reply card
Dowty Nucleonics Ltd
Elliott Bros (London) Ltd
Fairey Aviation Co Ltd, The
Hawker Siddeley Nuclear Power Co Ltd
Pye Ltd
Solartron Electronic Group Ltd
Sunvic Controls Ltd

SLOTTED ANGLES—STEEL & ALUMINIUM
★ Circle *No 835* on reply card
Dexion Ltd
Fisher & Ludlow Ltd
General Steel Group
Norwood Steel Equipment Ltd
Southborough (Weybridge) Ltd

SOLENOIDS
★ Circle *No 836* on reply card
British Thomson-Houston Co Ltd, The
Electro Methods Ltd
Hendrey Relays Ltd
Jones & Stevens Ltd
Lock & Co Ltd, A. M.
Phillips Control (GB) Ltd
Westool Ltd

SOURCE HOLDERS
★ Circle *No 837* on reply card
Lock & Co Ltd, A. M.
Research & Control Instruments Ltd
Western Detail Mfrs Ltd

SPECTROMETERS—ALPHA-RAY
★ Circle *No 838* on reply card
General Radiological Ltd

SPECTROMETERS—BETA-RAY
★ Circle *No 839* on reply card
Cuthbert Ltd, Ralph
General Radiological Ltd

SPECTROMETERS—GAMMA-RAY
★ Circle *No 840* on reply card
Dynatron Radio Ltd
Ekco Electronics Ltd
General Radiological Ltd
Isotope Developments Ltd
Nuclear Enterprises (GB) Ltd

SPECTROMETERS—INFRA-RED
★ Circle *No 841* on reply card
Gallenkamp & Co Ltd, A.
Hilger & Watts Ltd
Mervyn Instruments
Paton Hawksley Ltd
Pye Ltd

SPECTROMETERS—MASS
★ Circle *No 842* on reply card
Curran Ltd, John (Neutron Diffraction)
Joyce, Loebl & Co Ltd
Metropolitan-Vickers Electrical Co Ltd
Vacuum Industrial Applications Ltd

SPECTROMETERS—ULTRAVIOLET
★ Circle *No 843* on reply card
Gallenkamp & Co Ltd, A.
Hilger & Watts Ltd
Joyce, Loebl & Co Ltd
Paton Hawksley Ltd
Pye Ltd

SPECTROMETERS—X-RAY
★ Circle *No 844* on reply card
Ekco Electronics Ltd
General Radiological Ltd
Hilger & Watts Ltd
Newton Victor Ltd
Paton Hawksley Ltd
Pye Ltd
Research & Control Instruments Ltd
Solartron Electronic Group Ltd
Solus-Schall Ltd

STABILIZERS—VOLTAGE
★ Circle *No 845* on reply card
Airmec Ltd
Allied Electronics Ltd
Doran Instrument Co Ltd
Ericsson Telephones Ltd
Ferranti Ltd
General Radiological Ltd
Gresham Transformers Ltd
Holiday & Hemmerdinger Ltd
Isenthal & Co Ltd
Leland Instruments Ltd
Lyons Ltd, Claude
Mullard Ltd
Research & Control Instruments Ltd
Servomex Controls Ltd
Tinsley & Co Ltd, H.

STATIC ELIMINATORS—NUCLEONIC
★ Circle *No 846* on reply card
Isotope Developments Ltd
Lock & Co Ltd, A. M.

STIRRERS—LABORATORY
★ Circle *No 847* on reply card
Apex Construction Ltd
Baird & Tatlock (London) Ltd
B. & K. Laboratories Ltd
Blundell & Crompton Ltd
Butterworth Bros Ltd
Cuthbert Ltd, Ralph
Gallenkamp & Co Ltd, A.
Griffin & George Ltd
Harris (Birmingham) Ltd, F. & R. M.
Kestner Evaporator & Engineering Co Ltd
Lang London Ltd
Laboratory Apparatus & Glass Blowing Co
Quickfit & Quartz Ltd
Scientific Furnishings Ltd
Shandon Scientific Co Ltd
Towers & Co Ltd, J. W.
Vicsons Ltd
Weyers Bros Ltd

STROBOSCOPES
★ Circle *No 848* on reply card
Allied Electronics Ltd
B. & K. Laboratories Ltd
Dawe Instruments Ltd
EMI Electronics Ltd
Lancashire Dynamo Electronic Products Ltd
Lyons Ltd, Claude
Research & Control Instruments Ltd
Savage & Parsons Ltd
Tinsley & Co Ltd, H.

SURVEY INSTRUMENTS—CAR & AIRBORNE
★ Circle *No 849* on reply card
Falk & Co Ltd, M.
Isotope Developments Ltd
Nash & Thompson Ltd
Nuclear Enterprises (GB) Ltd
Ross Ensign Ltd
Siemens Edison Swan Ltd

SURVEY INSTRUMENTS—PORTABLE
★ Circle *No 850* on reply card
Appleby & Ireland Ltd
Avo Ltd
Burndept Ltd
Dynatron Radio Ltd
Ekco Electronics Ltd
Ericsson Telephones Ltd
Falk & Co Ltd, M.
General Radiological Ltd
Hendrey Relays Ltd
Hilger & Watts Ltd
Integra, Leeds & Northrup Ltd
Isotope Developments Ltd
Labgear Ltd
Nuclear Enterprises (GB) Ltd
Panax Equipment Ltd
Plessey Nucleonics Ltd
Pye Ltd
Research & Control Instruments Ltd
Shandon Scientific Co Ltd

SYNCHROS
★ Circle *No 851* on reply card
Appleby & Ireland Ltd
Austinlite Ltd
British Thomson-Houston Co Ltd, The
Elliott Bros (London) Ltd
Kent Ltd, George
Ketay Ltd
Muirhead & Co Ltd
Plessey Nucleonics Ltd
Pullin & Co Ltd, R. B.

TACHOMETERS
★ Circle *No 852* on reply card
Allied Electronics Ltd
Baird & Tatlock (London) Ltd
B. & K. Laboratories Ltd (electronic)
British Physical Laboratories
British Thomson-Houston Co Ltd, The
CNS Instruments Ltd
Dowty Nucleonics Ltd
Electro Methods Ltd
Elliott Bros (London) Ltd
EMI Electronics Ltd
English Electric Co Ltd, The
Ericsson Telephones Ltd
Evershed & Vignoles Ltd
General Electric Co Ltd, The
Honeywell-Brown Ltd
Ketay Ltd
Labgear Ltd
Lancashire Dynamo Electronic Products Ltd
Leland Instruments Ltd
Pullin & Co Ltd, R. B.
Racal Engineering Ltd
Record Electrical Co Ltd, The
Salford Electrical Instruments Ltd
Sangamo Weston Ltd
Shandon Scientific Co Ltd
Smiths Industrial Instruments Ltd

TANKS—ZINC BROMIDE WINDOW
★ Circle *No 853* on reply card
Evans & Son (Portsmouth) Ltd, J.
Harris (Birmingham) Ltd, F. & R. M.
Laboratory Apparatus & Glass Blowing Co
Marine & Industrial Plastics Ltd
Mendip (Chemical Engineering) Ltd
Power-Gas Corporation Ltd
QVF Ltd

TELEMETERING SYSTEMS
★ Circle *No 854* on reply card
Appleby & Ireland Ltd
Armstrong Whitworth Aircraft Ltd, Sir W. G.
Bailey Meters & Controls Ltd
Burndept Ltd
Cheltenham Auto Controls Ltd
Electronic Instruments Ltd
Elliott Bros (London) Ltd
EMI Electronics Ltd
Evershed & Vignoles Ltd
Fielden Electronics Ltd

TELEMETERING SYSTEMS—*continued*
Foxboro Yoxall Ltd
General Electric Co Ltd, The
Integra, Leeds & Northrup Ltd
Kent Ltd, George
Lancashire Dynamo Electronic Products Ltd
Muirhead & Co Ltd
Nuclear Engineering Ltd
Parkinson & Cowan Ltd
Pye Ltd
Rank Cintel Ltd
Rotameter Mfg Ltd
Salford Electrical Instruments Ltd
Southern Instruments (Computer Division)
Standard Telephones & Cables Ltd
Sunvic Controls Ltd
Thompson Ltd, J. Langham

TELESCOPES—INDUSTRIAL & LABORATORY
★ Circle *No 855* on reply card
Avimo Ltd
Baker of London, Ltd, C.
Hilger & Watts Ltd
Ross Ensign Ltd

TELEVISION—INDUSTRIAL
★ Circle *No 856* on reply card
Armstrong Whitworth Aircraft Ltd, Sir W. G.
B. & K. Laboratories Ltd
EMI Electronics Ltd
Lancashire Dynamo Electronic Products Ltd
Livingston Laboratories Ltd
Marconi's Wireless Telegraph Co Ltd
Pye Ltd
Rank Cintel Ltd
Research & Control Instruments Ltd

TEST EQUIPMENT—INSTRUMENT
★ Circle *No 857* on reply card
Allied Electronics Ltd
Armstrong Whitworth Aircraft Ltd, Sir W. G.
Avimo Ltd
Avo Ltd
Barnet Instruments Ltd
B. & K. Laboratories Ltd
Boulton Paul Aircraft Ltd
British Physical Laboratories
Bryans Aeroquipment Ltd
Cambridge Instrument Co Ltd
Cawkell Research & Electronics Ltd
Cossor Instruments Ltd
Doran Instrument Co Ltd
Electronic Instruments Ltd
Endecotts (Filters) Ltd
Ericsson Telephones Ltd
Evershed & Vignoles Ltd
Ferranti Ltd
Furzehill Laboratories Ltd
Gamma-Rays Ltd
General Electric Co Ltd, The
General Radiological Ltd
Glass Developments Ltd
Harvey Electronics Ltd
Holiday & Hemmerdinger Ltd
Ionic Instruments (London) Ltd
Leland Instruments Ltd
Livingston Laboratories Ltd
Lock & Co Ltd, A. M.
Madan & Co Ltd, Charles S.
Measuring Instruments (Pullin) Ltd
Muirhead & Co Ltd
Mullard Ltd
Nagard Ltd
Panax Equipment Ltd
Plessey Nucleonics Ltd
Research & Control Instruments Ltd
Salford Electrical Instruments Ltd
Sealey Engineering Co
Shandon Scientific Co Ltd
Solartron Electronic Group Ltd
Sullivan Ltd, H. W.
Tinsley & Co Ltd, H.
Venner Ltd
Weyers Bros Ltd
Winston Electronics Ltd

THERMISTORS
★ Circle *No 858* on reply card
B. & K. Laboratories Ltd
Holiday & Hemmerdinger Ltd
Standard Telephones & Cables Ltd

THERMOCOUPLES
★ Circle *No 859* on reply card
Baker Platinum Div, Engelhard Industries Ltd
Cambridge Instrument Co Ltd
Electrothermal Engineering Ltd
Elliott Bros (London) Ltd
Fleischmann (London) Ltd
Foster Instrument Co Ltd
General Electric Co Ltd, The
Hilger & Watts Ltd
Honeywell-Brown Ltd
Integra, Leeds & Northrup Ltd
KDG Instruments Ltd
Kelvin & Hughes Ltd
Kent Ltd, George
Johnson, Matthey & Co Ltd
Kidde Co Ltd, The Walter
Lock & Co Ltd, A. M.
Research & Control Instruments Ltd
Sangamo Weston Ltd
Sheffield Smelting Co Ltd
Spembly Ltd
Standard Telephones & Cables Ltd
Thermocontrol Installations Co Ltd
Towers & Co Ltd, J. W.
West Instruments Ltd
White Electrical Instrument Co Ltd

THERMOMETERS—DIAL
★ Circle *No 860* on reply card
Accurate Recording Instrument Co Ltd
Barnet Instruments Ltd
British Steam Specialties Ltd
British Rototherm Co Ltd, The
Cambridge Instrument Co Ltd
Casella & Co Ltd, C. F.
Darton & Co Ltd, F.
Griffin & George Ltd
KDG Instruments Ltd
Negretti & Zambra Ltd

THERMOMETERS—DIAL—*continued*
Shandon Scientific Co Ltd
Superheater Co Ltd, The
Taylor Controls Ltd
Teddington Industrial Equipment Ltd
Thermocontrol Installations Co Ltd

THERMOMETERS—DIFFERENTIAL
★ Circle *No 861* on reply card
Accurate Recording Instrument Co, The
Cambridge Instrument Co Ltd
Negretti & Zambra Ltd

THERMOMETERS—REMOTE READING
★ Circle *No 862* on reply card
Accurate Recording Instrument Co Ltd
Barnet Instruments Ltd
British Rototherm Co Ltd, The
British Steam Specialties Ltd
Cambridge Instrument Co Ltd
Elliott Brothers (London) Ltd
Fielden Electronics Ltd
Kent Ltd, George
KDG Instruments Ltd
Leland Instruments Ltd
Negretti & Zambra Ltd
Savage & Parsons Ltd
Taylor-Short & Mason Ltd
Teddington Industrial Equipment Ltd
Thermocontrol Installations Co Ltd

THERMOMETERS—REMOTE READING, MULTIPOINT
★ Circle *No 863* on reply card
Cambridge Instrument Co Ltd
Elliott Bros (London) Ltd
Kent Ltd, George
Lock & Co Ltd, A. M.
Negretti & Zambra Ltd

THERMOSTATS
★ Circle *No 864* on reply card
Accurate Recording Instrument Co Ltd
Baker & Sons (Sales) Ltd, P. W.
Electrothermal Engineering Ltd
General Electric Co Ltd, The
Gordon & Co Ltd, James
Honeywell-Brown Ltd
Monitor Patent Safety Devices Ltd
Negretti & Zambra Ltd
Research & Control Instruments Ltd
Salford Electrical Instruments Ltd
Stonebridge Electrical Co Ltd
Sunvic Controls Ltd
Servis Recorders Ltd
Stonebridge Electrical Co Ltd
Sunvic Controls Ltd
Teddington Industrial Equipment Ltd
Thermocontrol Installations Co Ltd
Weyers Bros Ltd

TIMING UNITS
★ Circle *No 865* on reply card
Allied Electronics Ltd
British Thomson-Houston Co Ltd, The
Chamberlain & Hookham Ltd
Elcontrol Ltd
Elliott Bros (London) Ltd
Ericsson Telephones Ltd
Fleming Radio (Developments) Ltd
General Radiological Ltd
Hendrey Relays Ltd
Hilger & Watts Ltd
Isotope Developments Ltd
KDG Instruments Ltd
Kent Ltd, George
Labgear Ltd
Lancashire Dynamo Electronic Products Ltd
Leland Instruments Ltd
Lock & Co Ltd, A. M.
Londex Ltd
Negretti & Zambra Ltd
Panax Equipment Ltd
Pringle & Sons (London) Ltd, Robert
Racal Engineering Ltd
Research & Control Instruments Ltd
Sangamo Weston Ltd
Smiths Industrial Instruments Ltd
Taylor Controls Ltd
Teddington Industrial Equipment Ltd
Trumeter Co Ltd
Venner Electronics Ltd

TITRATION APPARATUS
★ Circle *No 866* on reply card
Baird & Tatlock (London) Ltd
Cambridge Instrument Co Ltd
Doran Instrument Co Ltd
Gallenkamp & Co Ltd, A.
Griffin & George Ltd
Lock & Co Ltd, A. M.
Loughborough Glass Co Ltd
Research & Control Instruments Ltd
Shandon Scientific Co Ltd
Towers & Co Ltd, J. W.

TONGS—REMOTE HANDLING
★ Circle *No 867* on reply card
Carter & Viner
General Radiological Ltd
HL Instruments Ltd
Laboratory Apparatus & Glass Blowing Co
Savage & Parsons Ltd
Townson & Mercer Ltd
Western Detail Mfrs Ltd

TOOLS—HAND
★ Circle *No 868* on reply card
Abingdon King Dick
Allen & Co Ltd, Edgar
Bridges & Co Ltd, S. N.
BSA Tools Ltd
Carter & Viner
General Radiological Ltd
HL Instruments Ltd
Jessop & Sons Ltd, William
Lorant & Co Ltd
Moss & Gamble Bros Ltd
Osborn & Co Ltd, Samuel
Palatine Tool & Engineering Co (Surbiton) Ltd
Savage & Parsons Ltd
Wilkinsons Tools Ltd

TRANSDUCERS
★ Circle *No 869* on reply card
Allied Electronics Ltd
Appleby & Ireland Ltd
Armstrong Whitworth Aircraft Ltd, Sir W. G.
B & K Laboratories Ltd
Barnet Instruments Ltd
Boulton Paul Aircraft Ltd
Cambridge Instrument Co Ltd
Cawkell Research & Electronics Ltd
Elliott Bros (London) Ltd
Evershed & Vignoles Ltd
General Electric Co Ltd, The
Glass Developments Ltd
Hirst Electronic Ltd
KDG Instruments Ltd
Lock & Co Ltd, A. M.
Mullard Ltd
New Electronic Products Ltd
Racal Engineering Ltd
Research & Control Instruments Ltd
Salford Electrical Instruments Ltd
Shandon Scientific Co Ltd
Solartron Electronic Group Ltd
Solex (Gauges) Ltd
Southern Instruments, Computer Division
Sullivan Ltd, H. W.
Sunvic Controls Ltd
Technical Ceramics Ltd
Texas Instruments Ltd
Weyers Bros Ltd

TRANSFORMERS—ELECTRONIC
★ Circle *No 870* on reply card
Armstrong Whitworth Aircraft Ltd, Sir W. G.
English Electric Co Ltd, The
Ferranti Ltd
General Electric Co Ltd, The
General Radiological Ltd
Gresham Transformers Ltd
Holiday & Hemmerdinger Ltd
Metropolitan-Vickers Electrical Co Ltd
Mullard Ltd
Plessey Nucleonics Ltd
Pye Ltd

TRANSFORMERS—INSTRUMENT
★ Circle *No 871* on reply card
Appleby & Ireland Ltd
British Thomson-Houston Co Ltd, The
Cossor Instruments Ltd
Crompton Parkinson Ltd
Cuthbert Ltd, Ralph
Electric Construction Co Ltd, The
Electronic Instruments Ltd
English Electric Co Ltd, The
Ferranti Ltd
General Electric Co Ltd, The
General Radiological Ltd
Gresham Transformers Ltd
Hackbridge & Hewittic Electric Co Ltd
Lorant & Co Ltd
Metropolitan-Vickers Electrical Co Ltd
Mullard Ltd
Plessey Nucleonics Ltd
Record Electrical Co Ltd, The
Sangamo Weston Ltd
White Electrical Instrument Co Ltd
Zenith Electric Co Ltd, The

TRANSFORMERS—RESONANT
★ Circle *No 872* on reply card
Ferranti Ltd
Gresham Transformers Ltd

TRANSFORMERS—VARIABLE
★ Circle *No 873* on reply card
General Electric Co Ltd, The
Livingston Laboratories Ltd
Lyons Ltd, Claude
Research & Control Instruments Ltd
Zenith Electric Co Ltd, The

TRANSISTORS
★ Circle *No 874* on reply card
B & K Laboratories Ltd
British Thomson-Houston Co Ltd, The
General Electric Co Ltd, The
Holiday & Hemmerdinger Ltd
Leland Instruments Ltd
Mullard Ltd
Pye Ltd
Plessey Nucleonics Ltd
Newmarket Transistors Ltd
Salford Electrical Instruments Ltd
Standard Telephones & Cables Ltd
Solartron Electronic Group Ltd
Texas Instruments Ltd

TRANSMITTERS—PRESSURE
★ Circle *No 875* on reply card
Appleby & Ireland Ltd
Bailey Meters & Controls Ltd
Cambridge Instrument Co Ltd
Elliott Bros (London) Ltd
Evershed & Vignoles Ltd
Fielden Electronics Ltd
Foxboro Yoxall Ltd
Kent Ltd, George
Negretti & Zambra Ltd
Salford Electrical Industries Ltd
Sunvic Controls Ltd
Thompson Ltd, J. Langham

TRANSMITTERS—DIFFERENTIAL PRESSURE
★ Circle *No 876* on reply card
Appleby & Ireland Ltd
Bailey Meters & Controls Ltd
Cheltenham Auto Controls Ltd
Elliott Bros (London) Ltd
Evershed & Vignoles Ltd
Fielden Electronics Ltd
Foxboro Yoxall Ltd
Kent Ltd, George
Salford Electrical Industries Ltd
Sunvic Controls Ltd
Thompson Ltd, J. Langham

UNISELECTORS
★ Circle *No 877* on reply card
Automatic Telephone & Electric Co Ltd
Ericsson Telephones Ltd
Siemens Edison Swan Ltd
Standard Telephones & Cables Ltd

VACUUM EQUIPMENT
★ Circle *No 878* on reply card
Ayling Nuclear Equipment Co
Barlow-Whitney Ltd
Edwards High Vacuum Ltd
General Radiological Ltd
Leybold Vacuum Sales Ltd
Metropolitan-Vickers Electrical Co Ltd, The
NGN Electrical Ltd
Pulsometer Engineering Co Ltd, The
Shandon Scientific Co Ltd
Vacuum Industrial Applications Ltd
Vacuum Research (Cambridge) Ltd
Worthington-Simpson Ltd

VACUUM GAUGES *(see Gauges)*

VACUUM PUMPS *(See Pumps)*

VACUUM TEST EQUIPMENT
★ Circle *No 879* on reply card
Barnet Instruments Ltd
Birch & Co Ltd, H. A.
Edwards High Vacuum Ltd
Elliott Bros (London) Ltd
Fleischmann (London) Ltd
General Electric Co Ltd, The
Leybold Vacuum Sales Ltd
NGN Electrical Ltd
Northey Rotary Compressors Ltd
Pulsometer Engineering Co Ltd, The
Sunvic Controls Ltd
Vacuum Industrial Applications Ltd

VACUUM TUBING
★ Circle *No 880* on reply card
Blundell & Crompton Ltd
Edwards High Vacuum Ltd
Fleischmann (London) Ltd
Gallenkamp & Co Ltd, A.
General Radiological Ltd
Glass Developments Ltd
Laboratory Apparatus & Glass Blowing Co
Leybold Vacuum Sales Ltd
NGN Electrical Ltd
Power Auxiliaries Ltd
Pulsometer Engineering Co Ltd, The
Vacuum Industrial Applications Ltd

VACUUM UNIONS
★ Circle *No 881* on reply card
Blundell & Crompton Ltd
Edwards High Vacuum Ltd
Fleischmann (London) Ltd
General Radiological Ltd
Leybold Vacuum Sales Ltd
NGN Electrical Ltd
Pulsometer Engineering Co Ltd, The
Vacuum Industrial Applications Ltd
Western Detail Mfrs Ltd

VACUUM VALVES
★ Circle *No 882* on reply card
Appleby & Ireland Ltd
BEN Patents Ltd
Blundell & Crompton Ltd
British Steam Specialties Ltd
Edwards High Vacuum Ltd
Fleischmann (London) Ltd

VACUUM VALVES—*continued*
General Electric Co Ltd, The
General Radiological Ltd
Hindle & Sons Ltd, Joshua
Holiday & Hemmerdinger Ltd
Inness & Co (Darlington) Ltd
IV Pressure Controllers Ltd
Lacy-Hulbert & Co Ltd
Leybold Vacuum Sales Ltd
NGN Electrical Ltd
Palatine Tool & Engineering Co (Surbiton) Ltd
Pulsometer Engineering Co Ltd, The
Vacuum Industrial Applications Ltd
Weir Valves Ltd
Western Detail Mfrs Ltd

VOLTMETERS—ELECTROMETER
★ Circle *No 883* on reply card
Baldwin Instrument Co Ltd
Cambridge Instrument Co Ltd
Ekco Electronics Ltd
Electronic Instruments Ltd
General Electric Co Ltd, The
Leland Instruments Ltd
Lock & Co Ltd, A. M.
McKellen Automation Ltd
Tinsley & Co Ltd, H.

VOLTMETERS—ELECTROSTATIC
★ Circle *No 884* on reply card
Cambridge Instrument Co Ltd
Ferranti Ltd
General Electric Co Ltd, The
Leland Instruments Ltd
Livingston Laboratories Ltd
Lock & Co Ltd, A. M.
McKellen Automation Ltd
Stonebridge Electrical Co Ltd
Tinsley & Co Ltd, H.

VOLTMETERS—RECORDING
★ Circle *No 885* on reply card
Cambridge Instrument Co Ltd
Elliott Bros (London) Ltd
Evershed & Vignoles Ltd
Fielden Electronics Ltd
General Electric Co Ltd, The
Honeywell-Brown Ltd
Kent Ltd, George
Livingston Laboratories Ltd
McKellen Automation Ltd
Record Electrical Co Ltd, The
Solartron Electronic Group Ltd
Stonebridge Electrical Co Ltd
White Electrical Instrument Co Ltd

VOLTMETERS—VALVE
★ Circle *No 886* on reply card
Airmec Ltd
Allied Electronics Ltd
Avo Ltd
Baldwin Instrument Co Ltd
B & K Laboratories Ltd
British Physical Laboratories
Cambridge Instrument Co Ltd
Cossor Instruments Ltd
Electronic Instruments Ltd
Furzehill Laboratories Ltd
General Electric Co Ltd, The

VOLTMETERS—VALVE—*continued*
Holiday & Hemmerdinger Ltd
IV Pressure Controllers Ltd
Leland Instruments Ltd
Livingston Laboratories Ltd
Lock & Co Ltd, A. M.
McKellen Automation Ltd
Nash & Thompson Ltd
Research & Control Instruments Ltd
Salford Electrical Instruments Ltd
Solartron Electronic Group Ltd
Wayne Kerr Laboratories Ltd
Winston Electronics Ltd

WATER STILLS
★ Circle *No 887* on reply card
Apex Construction Ltd
Baird & Tatlock (London) Ltd
Bennett Sons & Shears Ltd
Blundell & Crompton Ltd
Cuthbert Ltd, Ralph
Fleischmann (London) Ltd
Gallenkamp & Co Ltd, A.
Griffin & George Ltd
Heat Exchangers Ltd
Loughborough Glass Co Ltd
Manesty Machines Ltd
QVF Ltd
Salford Electrical Instruments Ltd
Scientific Furnishings Ltd
Thermal Syndicate Ltd, The
Towers & Co Ltd, J. W.

WIRE
★ Circle *No 888* on reply card
British Insulated Callender's Cables Ltd
Fox & Co Ltd, Samuel
General Electric Co Ltd, The
Holiday & Hemmerdinger Ltd
Leland Instruments Ltd
London Metal Warehouses Ltd
Stainless Steel Wire Co Ltd
United Steel Companies Ltd, The
Wandleside Cable Works Ltd

WIRING ACCESSORIES
★ Circle *No 889* on reply card
Crabtree & Co Ltd, J. A.
CWC Equipment Ltd
General Electric Co Ltd, The
Holiday & Hemmerdinger Ltd

X-RAY CRYSTALLOGRAPHY APPARATUS
★ Circle *No 890* on reply card
Ashmore, Benson, Pease & Co
Curran Ltd, John (Neutron)
General Radiological Ltd
Hilger & Watts Ltd
Joyce, Loebl & Co Ltd
Kodak Ltd
Labgear Ltd
Metropolitan-Vickers Electrical Co Ltd
Newton Victor Ltd
Research & Control Instruments Ltd
Salford Electrical Instruments Ltd
Solus-Schall Ltd

X-RAY RADIOGRAPHY APPARATUS
(See Radiography Apparatus—X-ray)

COMPANY ADDRESSES

ABBOFLEX LTD, Abboflex Works, Walnut Tree Close, Guildford, Surrey *tel:* Guildford 5893
ABINGDON KING DICK, King's Rd, Birmingham, 11 *tel:* Acocks Green 2881
ABRASIVE DEVELOPMENTS LTD, High St, Henley-in-Arden, Nr Birmingham *tel:* Henley-in-Arden 160
ABRIL CORPORATION (GT BRITAIN) LTD, Golden Mile Works, Bridgend, Glam *tel:* Bridgend 821
ACALOR (1948) LTD, Kelvin Way, Crawley, Sussex *tel:* Crawley 1571
ACCLES & POLLOCK LTD, Oldbury, Birmingham *tel:* Broadwell 1500
ACCURATE RECORDING INSTRUMENT CO (ARIC, LTD), THE Garth Rd, Morden, Surrey *tel:* Derwent 2211
ACETYLENE GENERATOR & TOOL CO LTD, 27 Howland St, London, W1 *tel:* Museum 4435
ACHESON COLLOIDS LTD, Prince Rock, Plymouth *tel:* Plymouth 66351
ADAM MACHINE EQUIPMENT LTD, 4 Grange St, St Albans, Herts *tel:* St Albans 56731
ADAMSON, DANIEL, & CO LTD, Dukinfield, Ches *tel:* Ashton-under-Lyne 2822
ADCOCK & SHIPLEY LTD, PO Box 22, Ash St, Leicester *tel:* Leicester 24154
ADCOLA PRODUCTS LTD, Gauden Rd, Clapham, London, SW4 *tel:* Macaulay 3101
ADVANCE COMPONENTS LTD, Roebuck Rd, Hainault, Essex *tel:* Hainault 4444
ADS RELAYS LTD, 12 Store St, London, WC1 *tel:* Museum 2453
AEI-JOHN THOMPSON NUCLEAR ENERGY CO LTD, Radbrooke Hall, Knutsford, Ches *tel:* Knutsford 3800
AEI LAMPS AND LIGHTING CO LTD, Melton Rd, Leicester *tel:* Leicester 61531
AERASPRAY ASSOCIATED LTD, 179/213 Thimble Mill La, Birmingham, 7 *tel:* East 1671
AEROX LTD, Lister Place, Hillington Industrial Estate, Glasgow, SW2 *tel:* Halfway 4615
AEW LTD, Imperial Works High St, Edgware, Middx *tel:* Edgware 5278
AIMER PRODUCTS LTD, 56 Rochester Place, London, NW1 *tel:* Gulliver 3618
AIR CONDITIONING CORPORATION (JEFFREYS) LTD, St George's Ho, Waterloo Rd, London, SE1 *tel:* Waterloo 4433
AIR CONTROL INSTALLATIONS LTD, Ruislip, Middlesex *tel:* Ruislip 4066
AIR INDUSTRIAL DEVELOPMENTS LTD, Aidspray Works, Shenstone, Nr Lichfield, Staffs *tel:* Shenstone 341
AIR PUMPS LTD, 8 Francis St, London, SW1 *tel:* Victoria 5878
AIRCRAFT ENGINEERING & JIGS LTD, Hargreaves Wks, Oldham, Lancs *tel:* Main (Oldham) 3818
AIRCRAFT - MARINE PRODUCTS (GREAT BRITAIN) LTD, 60 Kingsley St, London, W1 *tel:* Regent 2517
AIRMEC LTD, Coronation Rd, High Wycombe, Bucks *tel:* High Wycombe 2060
AIRNESCO PRODUCTS LTD, Strood, Rochester, Kent *tel:* Strood 78310
AIRSCREW CO & JICWOOD LTD, THE, Weybridge, Surrey *tel:* Weybridge 2242
AITON & CO LTD, Stores Rd, Derby *tel:* 47111
AK FANS LTD, 20 Upper Park Rd, London, NW3 *tel:* Primrose 5969
ALBRIGHT & WILSON (MFG) LTD, Oldbury, Nr Birmingham *tel:* Broadwell 1595
ALDESLEY ENGINEERS LTD, Aldesley Rd, Tettenhall, Wolverhampton *tel:* Wolverhampton 52071
ALDIS BROS LTD, Priory Works, Sarehole Rd, Birmingham, 28 *tel:* Springfield 3343
ALFA-LAVAL CO LTD, Great West Rd, Brentford, Middx *tel:* Ealing 0116
ALEXANDER CONTROLS LTD, Reddicap Hill, Sutton Coldfield, Warwicks *tel:* Sutton Coldfield 5227
ALLDAY & CO LTD, WILLIAM, Alcosa Works, Stourport-on-Severn, Worcs *tel:* Stourport 311
ALLDAY & ONIONS LTD, Great West Works, Birmingham, 11 *tel:* Victoria 2251
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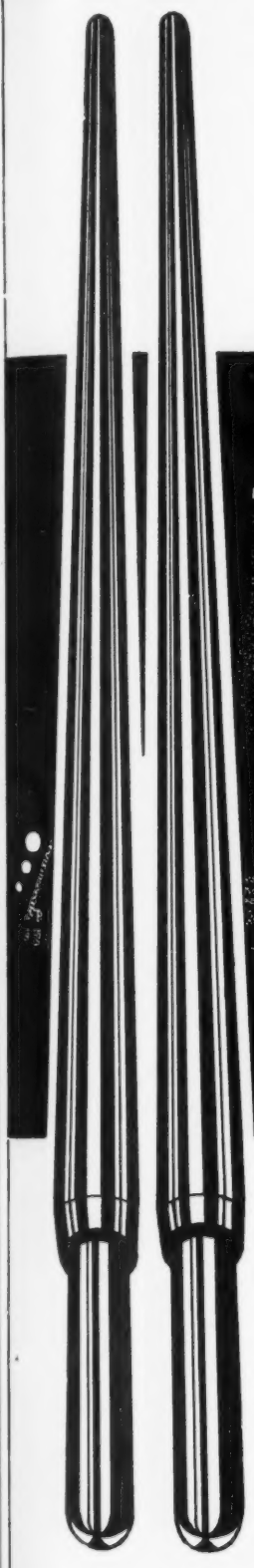

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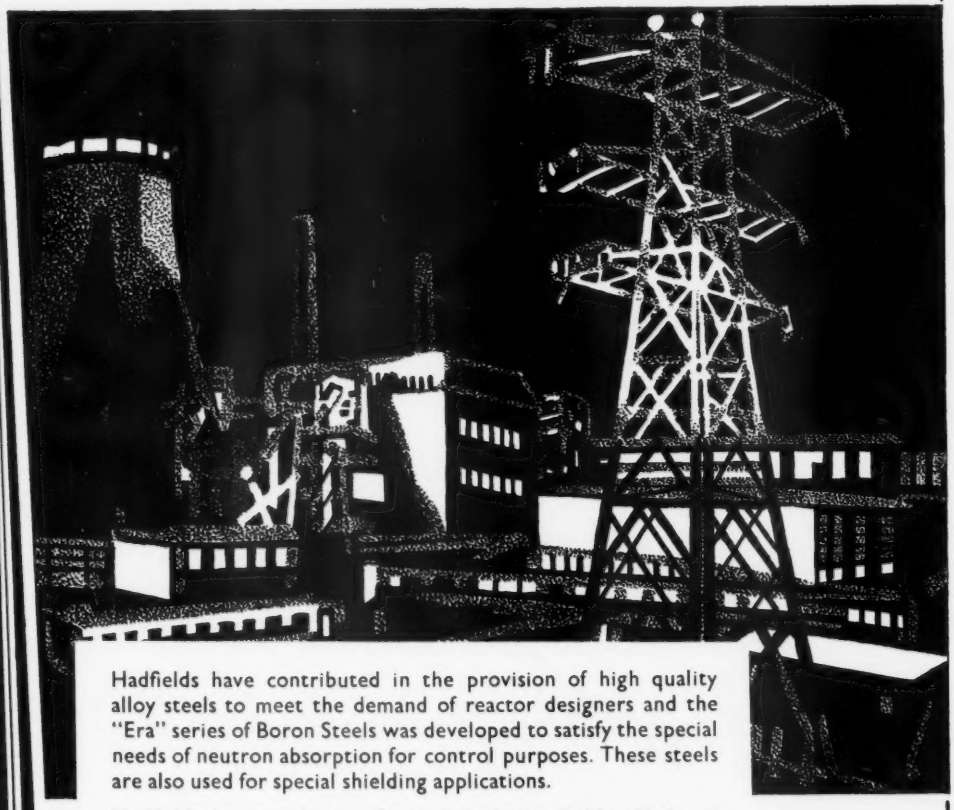

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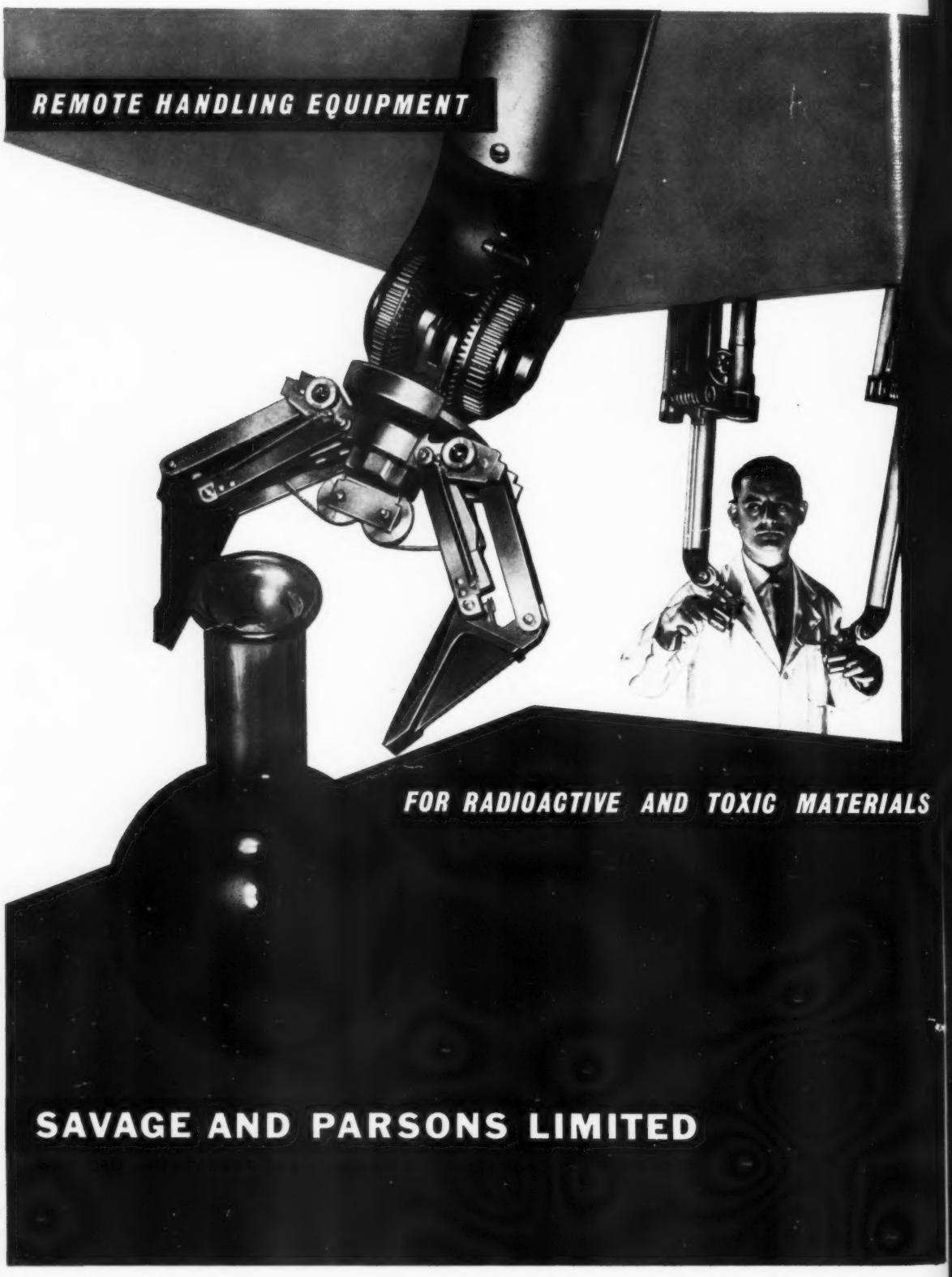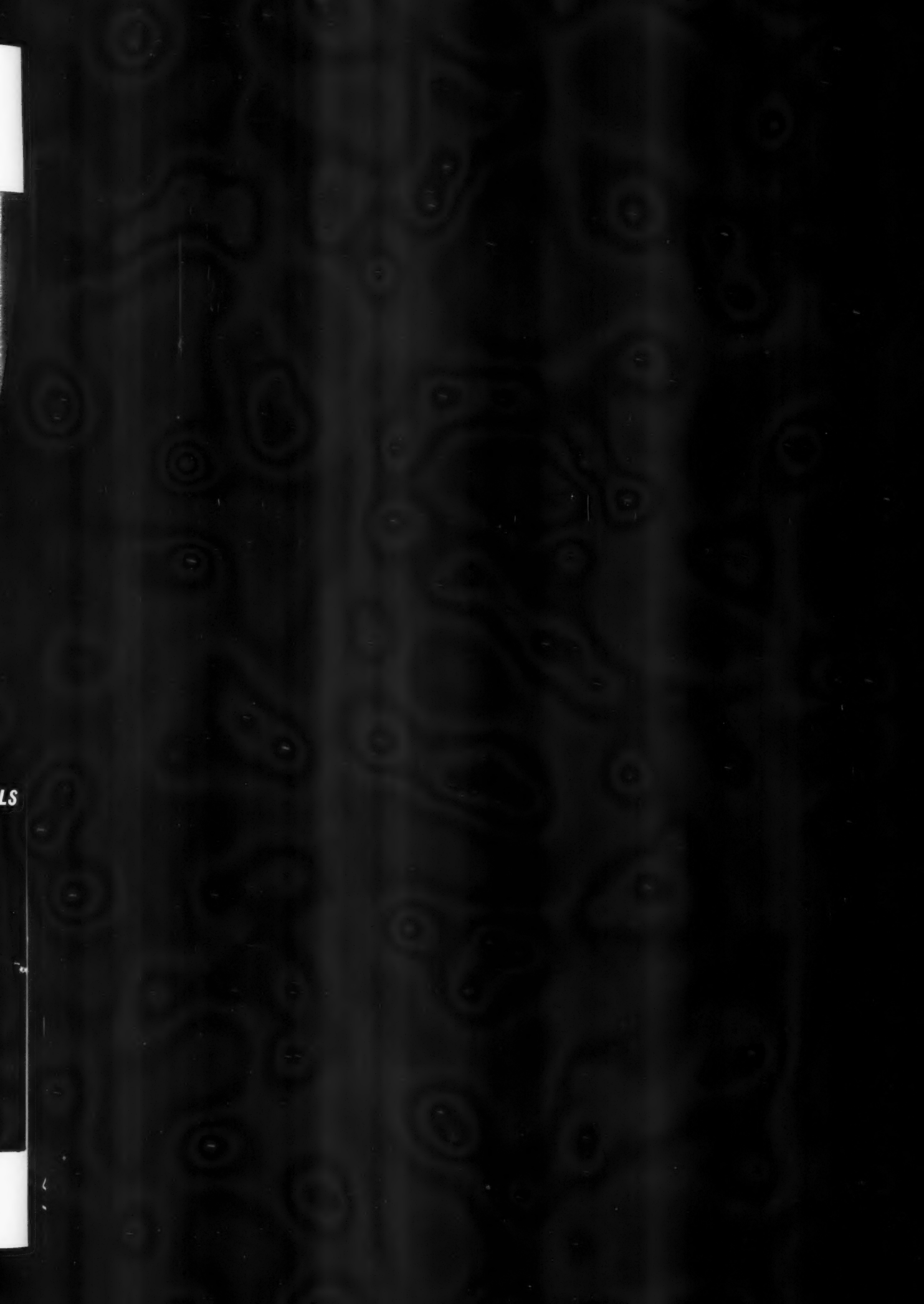
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